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INVESTIGATIONS OF NEONATAL NOSOCOMIAL SALMONELLOSIS

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Investigations of Nosocomial Neonatal Salmonellosis submitted by Margaret Elizabeth King in partial fulfillment of the requirements for the degree of Master of Nursing.

DEDICATION

To my family.

M.E.K.

ABSTRACT

The purpose of this exploratory study was to investigate two outbreaks of S. california in the newborn nurseries of a large city hospital with a view to determining the mode of spread of the infection, delineating the extent of dissemination of the disease outside of the hospital, exploring factors predisposing to the development of the disease, and assessing the effects of the infection on subsequent growth patterns of infants involved.

The study population reviewed consisted of infants born at the hospital during the outbreak periods who still resided in Edmonton (N=148). The observational nature of the study precluded the manipulation of any experimental variables.

The organism appears to have been introduced into the nursery environment through an infant infected by her mother at parturition. Once introduced, however, a reservoir of infection developed from which dissemination appears to have occurred for ten months. Despite many attempts to discover the source, it could not be located.

To determine the extent of the dissemination of the disease to the community, a stool culture survey was conducted of all infants (N=278) who had been in the neonatal intensive care unit of the hospital between the documented outbreaks. Only one additional case, probably associated with the infection problem,

was uncovered. After the second outbreak, prospective stool culturing study of all newborns on their fifth day of life revealed three additional cases.

Several factors were noted to be associated with the development of Salmonellosis: length of hospitalization; formula-feeding; birth weight; phototherapy; delivery by Caesarian-section; and head circumference at birth. The best predictor of infection in this group of infants was their length of hospitalization.

In assessing growth patterns among infants born at the hospital during the epidemic periods, neonatal Salmonellal infection was associated with a negative influence on weight gain, linear growth, and head circumference between birth and three months of age.

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During the early stages of the study, Dr. James Howell, Dr. Frank White, and Dr. Peter Patterson provided valuable assistance. The comments of Dr. Adrian Jones on aspects of growth were valuable in later stages of the study. Special thanks are due to Dr. Margaret Finlayson for her insight into the nature of the problem, and willing counsel throughout the study.

Many nurses, both hospital and community based, have assisted me in the collection of the data presented here. I am grateful for their assistance and appreciative of their concern over the problems which I have explored in the paper.

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CHAPTER I

INTRODUCTION

Problem, Objectives, and Purpose

Infections acquired in hospitals have the potential of increasing patient discomfort, prolonging hospitalization, extending morbidity, and increasing the risk of mortality (Streeter, Dunn, and Lepper, 1967). Newborn infants are among these who are most susceptible to infection (Dixon, 1977). This observation is supported by the finding that overall infection rates in neonatal intensive care units may be as high as 15.3% (Hemmingway, Overall, and Britt, 1976). The general problem explored in this study was that of the immediate and long-term effects of two nosocomial outbreaks of Salmonella california on the health of the infants involved. Following the investigation of the second outbreak, a search for additional cases in the community was conducted. A follow-up study of all infected infants was carried out to assess the effects of a neonatal Salmonellal infection on growth patterns during the first year of life.

While nosocomial (hospital-acquired) infections are of concern first and foremost to the patient and his family, there

are other important implications. An outbreak of an infectious disease in a hospital setting can disrupt the institution's ability to provide a high standard of care to the community due to the closure of wards and the restriction of admissions. In addition, there may be transmission of the organism to other patients, to hospital staff, and beyond the confines of the hospital, to the community at large. The overall objective in this study was to investigate the outbreaks of Salmonellosis with a view to controlling the dissemination of disease, and preventing the occurrence of further related outbreaks.

The specific research objectives centred upon:

(i) characterizing the outbreak by the epidemiological variables of person, place, and time;

(ii) identifying risk factors associated with the development of the disease;

(iii) identifying the mode(s) of transmission of the infecting agent;

(iv) describing the symptomatology of those affected;

(v) identifying the extent of dissemination of the disease from the hospital to the community between the outbreaks; and

(vi) examining the effects of the resulting morbidity in patients in terms of alterations in growth patterns during the first year following infection.

The study of factors affecting the transmission of nosocomial infections has considerable importance for all health care workers. The control and prevention of infection is a complex problem that requires the coordination and cooperation of all personnel (Chavigny, 1977). As the only members of the health care team in twenty-four hour contact with the patient, an outbreak of an illness which is propogated by cross-infection can cause considerable consternation to nurses (Cragg, 1979). Whether working at the bedside, in administration, as a specialist in infection control, or in public health, nurses should be aware of measures utilized in identifying, controlling, and preventing cross-infection (Anderson and Himmelsbach, 1967). The purpose of this study is to develop a global view of the immediate and long-term consequences of a nosocomial infection in a neonatal unit, with emphasis on the implications for nursing care.

Need for the Study

The cost of nosocomial outbreaks is formidable whether measured in terms of financial expenditures or patient discomfort, morbidity, and mortality. In a study at the Ottawa General Hospital, Westwood, Legace, and Mitchell (1974) estimated that 7.9% of all patients admitted developed nosocomial infections during their hospitalization. This represents an infection for

one out of every thirteen patients hospitalized. The estimated cost in terms of prolonged hospitalization represented over $800,000 per annum for the 600-bed hospital (p.772). Comparable figures for American hospitals listed in the study showed infection rates ranging from 3.5% in community-based hospitals to 15.5% in a large university-affiliated teaching hospital.

Other American studies show overall nosocomial infection rates ranging from 3.5 to 20% (Feingold, 1970; Hewitt and Sandford, 1974; Riley, 1969, 1977; Wengel, Osterman, and Hunting, 1976). The national cost for prolonged hospitalization in the United States is estimated at $1.5 billion annually based on infection rates of 5% and an estimated increase in expenses of $1,000 for each of the 1.5 million patients afflicted (Riley, 1977, p.1265).

Information on infection rates in newborn nurseries is scarce. In a study done by the Centre for Disease Control in Atlanta (1974) the neonatal rate of infection was 1.5%. This lower rate may partly reflect the practice of early discharge reported in most hospitals' statistics (p.5). Intensive care units for neonates appear to have higher infection rates. In an extensive surveillance program in one such unit, Hemmingway, Overall, and Britt found an infection rate of 15.3% over a forty-one month period (1976).

While the percentage of enteric infections in neonatal units is not reported, there are many articles in the literature documenting nursery outbreaks of gastrointestinal illness (e.g., Chrystie, Totterdell, and Banatuala, 1978; Guerrant, Dickens, Wenzel, and Kapikian, 1976; Rowe, Giles, and Brown, 1967).

Salmonella species are the infecting agents in a large proportion of the reported hospital epidemics for this age group. While the number of infants involved per epidemic is usually small, the reported case-fatality rate can be as high as 7.7% (Ip, Sin, Chan, Tse, and Teoh-Chan, 1972). As infants excrete Salmonella species longer than adults (Hornick, 1977), nursery outbreaks caused by these agents represent not just increase of hospital costs, but a potential cost to the community through increased secondary spread.

While the potential for community spread is recognized, this author found only one article which acknowledged dissemination to the community at large had actually occurred (Teoh-Chan, Chan, Tse, Sin, Ip, and Lan, 1976). The community was implicated as the reservoir of the agent in a few articles (e.g., Berant, Wagner, Cohen, and Kaufstein, 1977; Mendis, de la Motte, Gunatillaka, and Nagaratnam); other investigators blamed the problem on hospital to hospital spread (e.g., Hirsch, Sapiro-Hirsch, Berger, Winter, Mayer, and Merzbach, 1965; Rice, Craven, and Wells, 1976).

There is a great potential for the spread of Salmonella within a hospital. (This aspect will be covered extensively in Chapter II.) No matter in which direction the spread has occurred - community to hospital, hospital to hospital, within hospital or hospital to community - all health care personnel must be alert to the potential of cross-infection and act quickly to ensure that this transmission of Salmonella does not occur.

Description of the Study

The outbreak investigations and the community survey undertaken to search for additional cases in this study are examples of observational field studies (Fox, 1970, p.269). In assessing the effects of neonatal Salmonellosis on subsequent growth patterns during the first year of life, a prospective analytic approach was used (p.294). All phases of the study should be considered to be exploratory rather than definitive.

Definitions

For the purpose of this study, the following definitions apply:

> Nosocomial Infection: "(A)ny infection acquired during hospitalization that was neither present nor incubating at the time of the patient's admission to the hospital" (Dixon, 1977, p.95).

High-Risk Newborn Infants: These include all infants who are assessed during the perinatal period by medical staff as needing close observation and/or additional nursing care. Included in this category are infants of less than 36 weeks gestation, babies with low birth weight, babies delivered by Caesarian-section, babies in respiratory distress, babies with low Apgar ratings, and babies with congenital abnormalities.

Neonatal Intensive Care Unit: This specialized newborn nursery unit is the centre of care for high-risk newborn infants, and for infants requiring phototherapy or postsurgical care (for surgery other than routine circumcision).

Nurse: In this study, nurse refers to any registered nurse, student nurse, or certified nursing aide caring for infants within the newborn nursery or the neonatal intensive care unit.

Newborn Nursery: This refers to a nursing unit comprised of three rooms housing normal newborn infants, and one room for high-risk newborns.

Rooming-In: In this study, rooming-in refers to the hospital's practice of allowing normal infants to stay in their mothers' rooms from 0800 to 2200 daily. Infants are returned to the nursery for the remainder of the night.

A further list of terms commonly utilized in epidemiology is contained in the Glossary in Appendix A.

Limitations

The author was dependent on infants' hospital records for much of the data collected. Two major factors related to this general limitation influenced the results of the study: (1) The same types of information were not necessarily documented on all

of the infants; and (2) observations of the infants were not carried out by the same individuals.

The statistical reliability of the questionnaire distributed to parents in the community survey was not established. Further, the time lapse between the discharge of the infants from the neonatal intensive care unit and the decision to undertake a community survey varied from one to five months. Up to another month was lost in collecting the data - a stool sample and a questionnaire. While infants tend to continue to excrete Salmonella species for several months (Hornick, 1977), some infants may possibly have recovered prior to the collection of the stool specimen.

The protocol for screening stool for Salmonella spp. in both the hospital outbreaks and community survey involved the collection of only one specimen. Rectal swabs were used when stool was not available, possibly further reducing the yield of positive cultures (Edgar and Lacey, 1963).

Due to mobility within the city population, several infants were lost to follow-up in the community survey. This was an even greater problem in attempting to collect information for the one year follow-up study designed to look for any long-term effects caused by the neonatal infection.

With the exception of the one year follow-up study, the nature of the data collected was primarily nominal. This is

characteristic of analysis of outbreak situations. According to Fox, Hall, and Elveback,

> Observational studies in a field setting ... comprise the bulk of epidemiology research. Observation is focused on events, chiefly possible 'exposures' and disease occurrence, which have occurred or are occurring in the study population ... (G)rouping of population members for analysis is on the basis of characteristics (age, race, sex, occupation, smoking, diet, family size, and so on) which were not and could not have been assigned by the investigator (1970, p.269).

Assumptions

As the only cases of Salmonella california cultured in Alberta during the time-frame of this study were in association with the neonatal intensive care unit under investigation, the assumption was made that any subsequent cases found among the high-risk infants in the community who had been in that unit would represent nosocomial rather than community-acquired infections.

Underlying Research Questions

The analysis of data collected during an outbreak investigation permits the development of hypotheses as to the source and mode of transmission of the infecting agent. Three major questions guided the collection of the data:

1. What persons were affected;
2. Where were these persons located within the hospital;
3. During what period of time were they affected; and
4. What factors were associated with the development of the disease?

Subsequent to the collection of the descriptive data related on the outbreak situations, further questions guided the study:

5. Was there transmission of S. california to infants in the nursery between the two documented outbreaks; and
6. Did this nosocomial infection during the neonatal period cause any long-term morbidity as measured in terms of a physical developmental lag?

Descriptive Data and Hypotheses

The data collected during the outbreaks and the community survey are presented in descriptive form, i.e., frequency tables, epidemic curves, and attack rate tables. On the basis of the data available the following indices were used: birthdate, sex, mode of delivery, gestational age, birth weight, symptoms, diet, nursery location, antibiotic therapy, and phototherapy. In assessing the growth patterns of the infected infants, the study was designed to test the following null hypotheses:

H_o: Weight gain during the first year of life is not affected by neonatal infection with S. california.

H_o: Linear growth during the first year of life is not affected by neonatal infection with S. california

H_o: Growth in head circumference during the first six months of life is not affected by neonatal infection with S. california.

Ethical Considerations

Permission to use data collected during the investigation of the outbreaks was granted by the Research Ethics Committee of the hospital involved. In addition, permission to use the patient's hospital records was given with the understanding that the individual's privacy would not be violated.

The Local Board of Health granted permission to use the growth data collected on infants at the Well Baby Clinics held throughout the city. Data collected on behalf of the City Health Department during the outbreaks were used with the permission of the Medical Officer of Health. Anonimity was assured.

Sequence of Analysis

The investigator has organized this report under four main sections. Chapter II consists of a review of selected pertinent literature. Chapter III contains an explanation of the research

design and the methodologies utilized. The data are analyzed and discussed in Chapter IV. Chapter V contains a summary of the study and implications for nursing. A glossary of epidemiologic terms, copies of the research instrument, and selected tables have been appended to the study.

CHAPTER II

REVIEW OF SELECTED LITERATURE

This literature review is intended to highlight the more important factors influencing nosocomial infections as they relate to this study. The following subject areas have been included: (1) infection and the neonate; (2) major influences on growth patterns during the first year of life; (3) Salmonella infections; (4) prevention and control of Salmonellosis in nurseries; and (5) implications of infection control for nurses. The final section is aimed at literature pertinent to the epidemiological research approach utilized in the study. Steps utilized in outbreak investigation are enumerated, hypothesis formulation is considered, and cohort analysis is reviewed.

Infection and the Neonate

At birth, infants emerge from a sterile environment into the microbial world (Goldman, Leclair, and Macone, 1973). The gastrointestinal tract is quickly colonized via contact with the mother's skin, fecal, and vaginal microflora, and from air and food. Breast-fed infants develop a stable microflora in their intestines and feces that contain few, if any, putrefactive

bacteria. Why breast milk is capable of suppressing putrefaction is unknown. Bottle-fed babies show the same fecal microecology as adults. The gram-negative anerobes, absent in breast-fed infants, are present in abundant numbers (Haenel, 1970).

Goldman et al. noted that colonization of the nose, nasopharynx, throat, umbilicus, and rectum of infants with microflora shows a different pattern in critically ill infants. Colonization is delayed beyond the usual three days noted in healthy breast-fed neonates, and when it does occur, gram-negative bacilli predominate. They think this may partially be due to antibiotic therapy, separation from the mother, and altered feeding patterns. Colonization with normal, non-pathogenic bacteria seems to inhibit colonization with more virulent pathogenic strains (1978). The first organisms to reach an infant tend to grow prolifically and stay with him for a long time (Thompson, 1965).

The neonate is vulnerable to most common bacterial, viral, fungal, and protozoal infections. There are two aspects of neonatal infections, however, which set them apart from those acquired by older age groups. Firstly, the neonate shows greater susceptibility to infectious agents which are often non-pathogenic to older children and adults outside of the geriatric age group (McKay, 1969). Secondly, the neonate's response to infection may differ dramatically from that in older age groups.

Fever is often absent during infection. The body temperature may actually fall in the presence of an overwhelming sepsis in the newborn. Coughing, which accompanies respiratory insult in other age groups, is also absent (Korones, 1976). Failure to feed well, lethargy, irritability, episodes of cyanosis, and vomiting may be the only indications of serious illness (McKay, 1969).

The defense mechanisms of neonates are not well understood although both cellular and humoral responses are known to be impaired (Altemeir and Smith, 1966). The neonate is generally unable to make antibodies in response to the presence of an antigen (Grams, 1978). In addition, the inflammatory response is affected by decreased circulating leukocytes which are inhibited in their phagocytic functions and in their ability to concentrate at the site of inflammation (Bellanti and Hurtago, 1976). This allows infectious agents to invade and spread more easily in the newborn. The infant's active immune response takes nine to twelve months to mature. Fortunately, some passive immunity is acquired prior to birth from the mother (Grams, 1978).

The infant acquires immunoglobulin G transplacentally from his mother. This provides immunity to certain infections. Neither IgA nor IgM are transferred, though. As these contain specific bactericidal antibodies to gram-negative organisms, the infant is at risk of developing gram-negative sepsis (Klaus and Fanaroff, 1973). The deficiency in secretory IgA may be partic-

ularly important in the development of infectious diarrhea in very young children (Rice, Craven, and Wells, 1976).

All classes of immunoglobulins, including IgA, are present in breast milk, with the highest concentrations being in colostrum (Goldman and Smith, 1972; Winberg and Wessner, 1971). In addition, some antibodies are present in breast milk that show a limited but specific reaction to Escherichia coli, Hemophilus, B. pertussis, streptococci, staphylococci, polio virus, and influenza viruses. Consequently, "(b)reast-fed babies not only have a decreased incidence of enteric infections, they are also less prone than bottle-fed babies to respiratory infections, otitis media, and allergic conditions" (Grams, 1978, p.342).

Premature infants are at a higher risk of developing infection than are full-term infants (Bellanti and Hurtago, 1976; Korones, 1976; McKay, 1969). There is an increase in the rate of IgG transferred during the last trimester. Thus, the premature infant has less protective circulating antibody at birth than does the full-term infant.

Other factors also contribute to the premature infant's susceptibility. The increased need for life support systems in this group provides added opportunity for invasion by infectious agents. Indwelling venous, arterial, and umbilical catheters provide routes for organisms to invade. The equipment used to protect the infant, such as the incubator, may be contaminated.

As well, the infant who requires care in an intensive care unit will be handled frequently by nurses, physicians, X-ray technicians, and laboratory technicians carrying out procedures designed to aid him. Anyone handling an infant may unwittingly transmit an infectious agent to him. "These organisms may be swallowed, inhaled, or gain entrance via abraded skin or denuded mucous membranes. Males are more often infected than females" (Klaus and Fanaroff, 1972, p.209).

Infections may also be acquired transplacentally by infants prior to birth. Premature rupturing of the membranes provides an additional opportunity for neonates to develop infection via an ascending infection in the mother. Finally, an infant may come in contact during the birth process with an infectious agent harboured in the birth canal (Klaus and Fanaroff, 1972; Korones, 1976; and McKay, 1969).

Major Influences on Growth During the First Year of Life

A child's growth during his first year of life can be affected by events occurring as far back as his conception. Maternal, fetal, and placental factors all influence intrauterine growth. Following birth, nutrition, illness, socioeconomic status, and psychological factors affect the child's potential to achieve his genetically determined maximum growth.

Maternal age, parity, socioeconomic status, health, and nutritional state exert a profound influence on fetal growth. Well-nourished white women in their twenties, married to professionals or business men, and having their second child are more likely to have normal well-grown infants than short, malnourished black adolescents or grand multiparas who are either unmarried or married to unskilled or unemployed laborers (Korones, 1976). Fetal growth can be retarded by the presence of toxemia, renal disease, advanced diabetes, and cardiovascular disease. High altitude decreases birth weight, but does not affect length at birth (Klaus and Fanaroff, 1973). Maternal usage of cigarettes can result in babies of lower birth weight and length (Abernathy, Greenburg, Wells, and Frazier, 1966; Garn, Shaw, and McCabe, 1977; and Klaus and Fanaroff, 1973). The effect of maternal malnutrition on fetal size is not immediately obvious. It appears that a severe, prolonged shortage of food is necessary before fetal growth will be affected (Klaus and Fanaroff, 1973).

Fetal growth can also be affected by fetal factors such as intrauterine infection (especially with rubella or cytomegalovirus), congenital malformations, and chromosomal abnormalities. These factors exert an influence during the first trimester when cell multiplication is the main factor in growth. The number of cells produced is reduced, resulting in a smaller infant (Korones, 1976). The other major "fetal" factor influencing growth is

multiple gestation. Up to thirty-five weeks gestation, little growth retardation is seen (Lubchenko, Hansman, and Boyd, 1966). Placental insufficiency may be responsible for the small size of twins born after thirty-five weeks (Korones, 1976).

Placental factors affecting growth appear to be poorly understood. Impaired functioning of the placenta may occur without any obvious malformation of the placenta or underlying disease in the mother. The result of this placental insufficiency, whatever its cause, is an undernourished infant of low birth weight (Korones, 1976).

All of the above factors can result in infants who are small for their gestational age at birth. A newborn infant weighing less than 2500 grams is considered to be of low birth weight. Infants of less than thirty-seven weeks gestation are considered to be "pre-term", while those born after thirty-seven weeks and weighing less than 2500 grams are "small-for-dates" (Falkner, 1977). Generally, infants who are pre-term but not small for their gestational age (SGA) will catch up with full-term infants in weight, length, and head circumference by three years of age. SGA infants will show progress but will not fully catch up to the normal term infants (Babson and Benda, 1976; Falkner, 1977; and Klaus and Fanaroff, 1973). When assessing subsequent growth in a pre-term infant, gestational age must be taken into consideration. Graphs are now available which allow for the clinical

assessment of infants of varying gestational age (Babson and Benda, 1976; Lubchenko, Hansman, and Backstrom, 1976).

Gestational age can be assessed by a combination of physical and neuorological findings. Dubowitz et al. devised a system which assigns numerical scores to each of 10 neurological and 11 physical signs. The sum of the scores is plotted on a graph which allows gestational age to be estimated accurately to within a two-week range (1970).

The weight, length, and head circumference of any child at birth are important indicators of future size. In a longitudinal study of 20,000 clinically normal infants born at term, Garn, Shaw, and McCabe demonstrated that "birth size is, for normal term infants, the most important single determinant of individual growth during the first seven years of life" (1977, p.1049). Infants in the lower percentiles for weight, height, and head circumference at birth remained in the lower percentiles throughout the seven-year study. Conversely, children in the higher percentiles at birth remained in the higher percentiles. This was true for males, females, blacks, and whites. Other racial groups were not mentioned in the report of the findings. In that study, socioeconomic status, maternal size, and tobacco usage during pregnancy were also found to exert an influence on subsequent growth. None of these factors, however, affected growth to the same extent as birth size. This finding allows deviations

from expected growth patterns to be detected. If a child who was in a high percentile for weight and height at birth drops to a lower percentile at one year of age, an investigation into the cause is warranted (Garn et al., 1977).

Linear growth occurs at a more constant rate than weight. A child's weight is subject to many fluctations caused by seasonal variations, illness, or nutritional impairment. Correction of the condition will result in catch-up growth by the child. Each child seems to have his own growth velocity curve. Once he is growing in accordance with this curve, he will not deflect from it for long unless his environment becomes and remains inadequate (Falkner, 1977).

Nutrition plays an important role in the child's growth during the first year of life. Weight gain will be affected by the choice of bottle-feeding or breast-feeding and by the age at which solids are introduced. In a study of birth weight doubling times, Neumann and Alpaugh followed 354 normal infants between 1973 and 1974. At the time of the study, only 15% of mothers were feeding their infants exclusively on breast milk to three months of age. The researchers found that bottle-fed babies had a greater relative weight gain compared to linear growth than breast-fed babies and speculate that part of the excess weight gain was due to earlier introduction of solids in the bottle-fed group. In addition, infants who are breast-fed expend more

energy when suckling than that required by the bottle-fed group to obtain their nourishment (Neumann and Alpaugh, 1976, p.472). Their findings of excessive weight gain in bottle-fed infants are supported by other authors in the field (e.g., Eid, 1970; Shukla, Forsythe, Anderson, and Marwah, 1972). The excessive weight gain among the bottle-fed babies in the Shukla study was not associated with any increased linear measurement (p.514).

The other important factor related to the rate at which infants gained weight in the Neumann study was sex. Males gained in both weight and length at a faster rate than females. Although various ethnic groups were examined in this Californian study population - Caucasian, Mexican-American, Oriental, and Black - no significant differences in birth weights were found. Birth weight itself influenced the age at which infants doubled their weight. Those who weighed least at birth doubled their weight sooner than the infants who were heavier at birth.

Ethnic differences in weight gains have been noted in other studies. Black infants seem to have patterns of growth that differ from those of white infants: smaller at birth but larger by the pre-school years (Garn et al., 1977).

Socioeconomic status (SES), while negatively influencing weight gain, is difficult to analyze as a factor separate from ethnic group, nutritional status, and size of parents. In a study of adults in Manhattan in 1962, Moore, Stunkard, and Srole

noted an inverse relationship between parental SES and obesity. A more recent study of children showed a similar trend among white girls. Among children whose parents were in the lower class, obesity was nine times more prevalent than among children of high SES by the age of six. The results showed a similar though less striking pattern for boys (Stunkard, d'Aquili, Fox, and Filion, 1972). The data unfortunately do not include infants. It should also be pointed out that low socioeconomic status is not equivalent to poverty.

Poverty, at one extreme end of the socioeconomic continuum, is entwined with malnutrition and infection (Lerner, 1969). The authors of a study on morbidity and growth of infants in rural Mexico state that studies of American and British infants probably don't give the best indication of the results of illness on growth, since their infants receive better medical care, and are more apt to exhibit catch-up growth following the illness. In a poor environment where undernutrition is prevalent, the severity of the illness is enhanced, and the possibility of catch-up growth is diminished. In the study it was found that upper respiratory illness did not influence growth. Repeated diarrheal illness, on the other hand, was associated with decreased weight gains. Height was not affected (Condon-Paoloni, Cravioto, Johnston, de Licardie, and Scholl, 1977). In studies in Uganda and the Gambia, Cole and Parkin examined the influence of in-

fection on malnutrition in children in terms of rates of growth. The disease entity which most severely affected growth rates in both countries was again gastroenteritis (1977). Bacterial infections of the gastrointestinal tract have an adverse influence on protein nutrition. In a poorly nourished child, diarrhea may begin as an acute infection and end as chronic diarrhea, perputuated by protein deficiency (Scrimshaw, Taylor, and Gordon, 1968).

Even in the United States, the poverty population (including some native Indian bands, Appalachians, and negroes in some depressed areas of the south) is considerably less healthy than the rest of the country. However, an interesting countervailing tendency with the more affluent strata of the non-poverty segment is developing, due to more prevalent coronary artery disease and stress-related diseases. "Considering total mortality (from all causes) and total morbidity (from all considerations and with all degrees of severity), one can expect a U-shaped curve: overall mortality and morbidity may be highest, or most prevalent among the poor and the well-to-do, and lowest or least prevalent among the middle strata of our population" (Lerner, 1969, p.111).

To measure socioeconomic status, education and income levels are established for occupations, which are then ranked. In Canada, much of the work in establishing a socioeconomic index has been undertaken by Blishen (1958; 1967). Census figures are

used as a data source. Until recently, only male occupations were reported on the assumption that the social status of the family is based on the occupational status of the male head of the household. However, more recently Hockey (1976) and Blishen and Carroll (1978) have devised socioeconomic indices for women.

Growth in infancy can also be affected by the quality of the relationship between the mother and the child (Bowlby, 1952). Infants who are given only the basic physical necessities will not thrive (Lozoff, Brittenham, Trause, Kennell, and Klaus, 1977). Recently, research on child care has been focused on maternal-infant attachment behaviours, with attention to interaction between mother and child within the first few hours after birth. In a small study of 28 primiparous women, it was found that mothers who had extended contact with their naked newborns right after birth and for a total of 16 hours during the first three days of life exhibited more fondling behaviours later than their cohorts who had only held their infants during scheduled feeding hours (Klaus, Jerauld, Kreger, McAlpine, Steffa, and Kennell, 1972). Lozoff et al., in a review of the pertinent literature suggest that the imposition of separation of mothers from their infants after delivery may tax the ability of the mothers to care for their babies, and especially may interfere with their ability to establish breast feeding. Lozoff advocates that for the healthy neonate and mother, social contact should be

continuous from birth to discharge from hospital. Klaus and Kennell concur, reasoning that affectional bonds may start forming before delivery, that they are fragile, and may be easily altered in the first few days of life (1970).

When a child is born pre-term or small for his gestational age, his fragile condition may demand more intensive nursing and medical care to ensure survival. In these cases, maternal interaction with the child in terms of even just touching the infant while visiting on a regular basis will increase the mother's self-confidence (Seashore, Leifer, Barnett, and Leiderman, 1973). In comparing mothering practices of women with pre-term or full-term infants, Leifer, Leiderman, Barnett, and Williams noted that mothers of full-term infants smiled at their infants and held them close more frequently. While the authors postulate that part of this difference may be due to differing lengths of separation from their infants, they also contend that the hormonal condition of the mother delivering at term influences the quality of maternal attachment, with mothers most ready to accept their infants soon after they have given birth (1972, p.1216).

While prolonged separation from the mother may subsequently alter growth patterns in infants nursed in NICU, occasionally treatments provided in these care units have also been implicated in some studies. Phototherapy, which is used to prevent hyperbilirubinemia in infants, is one of these treatments which has

been studied (Hodgeman and Teberg, 1970; Wu, Lim, Hodgeman, Kokosky, and Teberg, 1974). While Wu et al. noted decreased weight gains in infants in the first four weeks of life who had undergone phototherapy, other studies looking at weight gains over periods of up to two years of age have found no prolonged adverse effects (Romanagnoli and Polidori, 1977; Teberg, Hodgeman, and Wu, 1977).

Salmonella Infections

Non-typhoidal Salmonellae are gram-negative, aerobic, non-capsulating bacteria which can be easily grown in culture (Hornick, 1977). To date, more than 2,000 different sero-types of Salmonella have been identified (White, 1979). Infection occurs when a sufficiently large number of bacteria have been ingested.

Salmonellosis usually presents as an enterocolitis with diarrhea and abdominal cramps. Nausea and vomiting may be present, and occasionally chills, fever, and malaise accompany the infection. The severity of the illness, and the number of symptoms present, depend on the sero-type involved and various host characteristics such as age and underlying disease status. The range of incubation periods is from 6 to 72 hours, with the average being 18 to 36 hours (Committee on Communicable Diseases Affecting Man, 1976).

After Salmonellae have been ingested, they multiply in the small intestine and colon, resulting in an inflammation of the lamina propria of the villae. Epithelial cells must be penetrated for infection to occur. If Salmonellae are not restrained by the intestinal mucosa and the lymphatic system, a bacteremia can occur. When a Salmonellal bacteremia is present, abscesses can form at almost any site. These localized infections most often occur at sites where there is previous underlying pathology (Hornick, 1977).

Reservoirs of Salmonellae

Salmonella species are found world-wide in various mammals, fowl, reptiles, and insects. Domestic animals used for human consumption are the largest reservoir of infection for man. Independent surveys conducted by the Health Protection Branch of Health and Welfare Canada in 1975 indicated that one-third of all chicken and turkeys marketed in Canada were contaminated with Salmonella (reported in White, 1979, p.3). It has been estimated in the United States that one to three percent of all domestic animals are infected. Crowded conditions prior to slaughter, and cross-contamination of carcasses in slaughterhouses can lead to as much as 50% of the meat marketed being contaminated (Hornick, 1977). By-products from the slaughterhouses such as bones,

feathers, meat-trim, and offal are used for animal feed. This frequently contaminated material reintroduces infection to domestic flocks and herds (Appleman and Appleman, 1968; Hornick, 1977). Salmonellae are heat sensitive and proper cooking of all meat, poultry, and eggs can reduce the incidence of disease in man.

Salmonellosis has resulted in children through handling pet turtles, baby chicks, ducklings, rabbits, cats, and dogs. Various medical and pharmaceutical products such as carmine dye, pepsin, and bile salts; thyroid, pancreatic, and adrenal cortical preparations; and human platelets used for transfusion have been contaminated (Appleman and Appleman, 1968; Baine, Gangarosa, Bennett, and Barker, 1973; Schroeder, Aserkoff, and Brachman, 1968; Werrin and Kronick, 1966). Infected humans excrete Salmonella in their feces, and occasionally in urine. These excretions then become possible sources of infection for others as well.

Factors Influencing Salmonellal Infections

Three major factors govern whether or not infection will occur after the ingestion of *Salmonella spp*. These include the number of organisms ingested, the pathogenicity of the species, and the ability of the host to resist infection. In healthy adults, as many as 100,000 to 1,000,000 organisms may be required

to cause an infection, although considerably fewer are capable of producing a carrier state (Hornick, 1977). In reviewing the history of a nine-month old boy with cystic fibrosis on antibiotic therapy, Lipson calculated that only 44 organisms, contained in contaminated porcine powdered pancreatin, had caused an infection with S. schwartzengrund (1976).

The various sero-types differ considerably in pathogenicity and virulence. Strains such as S. typhimurium have high pathogenicity and moderate virulence. This sero-type represents the most frequent human isolate. In addition to causing gastroenteritis, it can invade the blood stream and urinary tract, and has been cultured from abscesses. S. choleraesuis is less pathogenic but causes a more serious illness. Bacteremia is usually associated with this infecting organism. An asymptomatic infection with S. choleraesuis is rare (Hornick, 1977). This author feels that the pathogenicity of organisms of low virulence is often underestimated due to the large number of cases which go undetected due to lack of symptoms (inapparent infections). In 1958, a protracted outbreak of S. tennessee occurred in a premature nursery in which 28 infants were infected over a 4-month period. Positive cultures were noted incidentally during an epidemiological survey of normal infant flora which was underway at the time of the outbreak. None of the infants infected had any symptoms of illness (Watt, Wegman, Brown, Schliessman,

Maupin, and Hemphill, 1958).

The most important host characteristics predisposing to infection with Salmonella spp. are age and health state. Infants and elderly people are more at risk of developing Salmonellosis than other age groups (Appleman and Appleman, 1968; Hornick, 1977; Rice, Craven, and Wells, 1976; White, 1979). In addition to increased morbidity, case-fatality rates are also higher among these groups (Baine et al., 1973). Immune deficiencies already discussed partially account for the susceptibility of infants to this infection. Immune resistance is altered again by advanced age.

Other medical conditions will alter the ability of individuals to fight infection. Patients with malignancies, systemic lupus erythematosis, renal failure, and cirrhotic liver disease have a higher than average incidence of Salmonellosis. These patients, when infected, have a higher incidence of bacteremia. In addition, sickle cell anemia, malaria, and bartonellosis actually predispose to Salmonellal infections although the reasons for this are not well understood (Baine et al., 1973; Hornick, 1977; Rice et al., 1976).

Over all age groups, there is no sex difference associated with Salmonellosis. In the under 20 age group though, significantly more males are infected than females while the reverse is true in the over 20 age group (Hornick, 1977).

Previous antibiotic therapy enhances susceptibility to Salmonellal infection. Adler, Anderson, Boring, and Nahamias describe a protracted outbreak of Salmonellosis in which 68% of the cases had been on antibiotic therapy previously. Comparing patients on the same ward during the outbreak, a statistically significant risk was associated with antibiotic administration (1970). These findings are supported by several other authors (Baine et al., 1973; Hirsch, Sapiro-Hirsch, Berger, Winter, Mayer, and Mertzbach, 1965; MacGregor and Reinhart Jr., 1973). Rosenthal proposes that the increased susceptibility may be due to suppression of normal bowel flora with subsequent overgrowth with Salmonella (1969).

Nursery-Associated Outbreaks of Salmonellosis

There are many reports of hospital-associated outbreaks of Salmonellosis. Two main patterns are observed: large common source outbreaks usually resulting from contaminated food, or relatively small outbreaks propagated by cross-infection. The majority of nursery outbreaks belong to the latter group.

The organism is frequently introduced into the nursery environment by an infant who has acquired the infection from his mother during the birth process (Abrams, Cochran, Holmes, Marsh, and Moore, 1966; Epstein et al., 1951; Public Health and Hospital

Laboratories, 1974; Rowe, Giles, and Brown, 1969).

Infection is spread from infant to infant either by staff or through contamination in the environment. Staff who are themselves infected can transmit the infection to the infants. Asymptomatic infected staff served as a reservoir of infection prolonging the duration of an outbreak as illustrated by Sanders, Sweeney, Friedman, Boring, Randall, and Polk in 1963. They report 62 asymptomatic excreters among hospital staff in a protracted outbreak of S. derby in a general hospital. Even though the staff may not be infected, they have been implicated in the transmission of Salmonella spp. through poor handwashing techniques in several outbreaks (e.g., Edgar and Lacey, 1963; Lintz, Kapila, Pilgrim, Tecson, Dorn, and Louria, 1976; Watt et al., 1958; Werrin and Kronick, 1966).

Several fomites have served as sources of infection. In a protracted hospital outbreak of S. indiana, Adler et al. cultured Salmonellae from "table tops, floors, sinks, sink drains, crib rails, venetian blinds, window sills, toys, a thermometer receptacle, a bedside wash basin, the inside of an isolette, and the scale used for weighing all infants" (1970, p.972). Watt et al. (1958) recovered S. tennessee from scales, a clean medicine table, a garbage cart, and a nurse's hands right after she had washed them. Other environmental items noted to be infected during outbreaks have included dust (Bate and James, 1958), de-

livery room resuscitators (Rubenstein and Fowler, 1955), a water bath used for heating formula (Epstein, Hochwald, and Ashe, 1951), fiberoptic endoscopes(Chmel and Armstrong, 1976), water-tanks and faucets (Mendis, de la Motte, Gunatillaka, and Nagaratnam, 1976), and delivery room suction apparatus (Ip, Sin, Chau, Tse, and Teoh-Chan, 1976). The liquid nature of infants' stools presumably contributes to gross environmental contamination.

Factors Affecting Epidemicity

The presence of an unrecognized Salmonellal infection in a hospitalized patient does not necessarily signal the beginning of an outbreak. MacGregor and Reinhart (1973) reported eight patients with acute Salmonellosis who were hospitalized without appropriate isolation precautions. Although their surroundings were extensively contaminated, none of the 265 patients and staff identified as contacts developed an infection. The authors conclude that in adult patients, a contaminated food or water source in which the Salmonellae can multiply is necessary for the propagation of the infection. Infants can be infected by cross-contamination due to the smaller sized inocculum required to infect. This author has noted that even in many reported outbreaks, cases and carriers of sero-types of Salmonella other than those responsible for the epidemic are present at the same time.

In an extensive investigation of an epidemic of S. johannesburg in the pediatric ward of a hospital in Hong Kong, Teoh-Chan and colleagues isolated S. anatum from three patients, S. derby from one, and S. newport from a further two on admission to hospital. Twenty-two children had S. johannesburg cultured from their stools on admission during the two-month study. The environment was heavily contaminated with both S. johannesburg and S. anatum, and two of the staff were discovered to be asymptomatic carriers of S. anatum and S. derby. Subsequently, one-quarter of all children admitted to the ward developed S. johannesburg. There were no secondary cases of any of the other sero-types (1977).

Ip et al. detected S. derby from an aysmptomatic infant during an outbreak of S. worthington in a newborn nursery. Four members of the medical and nursing staff were noted to be carrying S. anatum. Again, only S. worthington spread (1976). During another outbreak lasting 32 months in two hospitals in Israel, Hirsch et al. noted the isolation of 31 sero-types other than S. edinburg which was responsible for the epidemic. None of the other sero-types spread.

While the differing size of the inocculum required to cause disease with various sero-types may account partially for the discrepancy in the ability of Salmonella spp. to spread, two other factors are commonly associated with epidemic strains: in-

troduction of a new sero-type to the community and, more commonly, multiple-drug resistant strains.

In several reported outbreaks, the species of Salmonella isolated was one not commonly found in the vicinity (Adler et al., 1970; Hirsh et al., 1965: Ip et al., 1976; and Rowe, Giles, and Brown, 1969). In two reported outbreaks, the Salmonella spp. had only recently become established in the community and was noted to be causing considerable illness (Mendis et al., 1976; Teoh-Chan et al., 1976). Hornick states that "(a)lthough information is scanty, it appears that acute, non-typhoidal enterocolitis does not confer immunity. Repeated attacks occur, even with the same sero-type" (1977, p.560). Nevertheless, new sero-types when introduced into a community, do appear to have a greater capacity to initiate outbreaks.

In outbreaks associated with more common Salmonella spp., multiple-drug resistant strains were implicated. Adler et al., 1970; Chmel and Armstrong, 1976; Edgar and Lacey, 1963; Hirsch et al., 1965; Lintz et al., 1976; Mendis et al., 1976; Rice et al., 1976; and Teoh-Chan et al., 1977, all report high degrees of resistance to many antibiotics in the sero-types isolated. Bissett, Abbott, and Wood reported their findings on antimicrobial resistance in 2,246 strains of Salmonella isolated in California (1974). In 32% of the isolates, there was resistance to at least one of the 12 antibiotics tested. Additionally, 77% of those

showing resistance were resistant to two or more antibiotics. Seventy percent of the sero-types showing multiple resistance had demonstrable R factors. These R factors are episomes which enable the host organism to transfer genes mediating antimicrobial resistance to other susceptible organisms (p.161). In this manner, other pathogenic bacteria can become resistant to the same antibiotics.

During the 32-month long outbreak of S. edinburg reported by Hirsch et al. (1965), cultures of two strains of enteropathogenic Escherichia coli with the same multiple drug-resistant patterns as the S. edinburg were isolated from pediatric patients five months before the outbreak began. One of these strains was subsequently responsible for some cross-infections as well (p.828). The authors maintain that an R factor may have been transferred from the E. coli to the Salmonellae. This would support findings of Aserkoff and Bennett (1969) in their duplication of this phenomenon in an animal model.

Multiple drug-resistance in Salmonella spp. can seriously hamper therapy for life-threatening sepsis. Lintz et al. report ten epidemiologically associated hospital cases of S. heidelberg in which most isolates were resistant to chloramphenical, ampicillin, sulphasoxazole, and tetracycline. In addition, many were also resistant to gentamycin and the trimethoprim-sulfamethoxazole combination. Eight of the ten patients presented died, with at

least five of the deaths attributable in part to their Salmonellal infections (1976).

Treatment

In the majority of cases of Salmonellosis, treatment is limited to maintenance of fluid and electrolyte balance. Antibiotic treatment in the absence of bacteremia, meningitis, or absesses is not advocated. Patients with Salmonellal enterocolitis frequently continue to excrete Salmonellae during treatment with antibiotics to which the organism is sensitive (Adler et al., 1970). Antibiotic therapy will, in fact, prolong the duration of excretion in those infected (Adler et al., 1970; Aserkoff and Bennett, 1969; Dixon, 1965; Hornick, 1977).

Carrier State

Infants once infected tend to excrete *Salmonella spp.* in their feces for longer periods than adults. Abrams et al. found that of ten infants infected with *S. newport*, four were still excreting Salmonellae at 8 months and 12 months (1966, p.622). Rowe et al. contend that infants who are infected prior to six weeks of age, will continue to excrete Salmonellae until they are taking an adult type diet (1969).

Prevention and Control of Salmonellosis in Nurseries

In the preceding section, it was noted that *Salmonella spp.* are often introduced into nurseries through infection of a neonate at birth. The frequency with which this occurs could be reduced by including a question on recent gastrointestinal illness in the obstetrical history. Mothers with recent histories of diarrhea could be isolated with their infants until enteric pathogens have been ruled out (Baine et al., 1973; Mendis et al., 1976; Rowe et al., 1969). By employing this method, Rowe et al. detected six new cases of Salmonellosis and one of Shigellosis in a 5-month period (p.563). As infection can also potentially be introduced by asymptomatic carriers among the staff, Epstein et al. recommend periodic stool cultures of all staff assigned to the nursery (1951). This practice is not advocated by all (Bartlett, Groschel, Mackell, Mallison, and Spaulding, 1974).

Ip et al. (1976) emphasize the importance of tracing the source of an outbreak in order to prevent a recurrence. When the source is environmental, it must be decontaminated or destroyed. If the source is a human carrier, contact between that person and patients should be eliminated (Rice et al.). All personnel should have stool cultures taken during and after an outbreak to check for carriage of *Salmonella spp.* Edgar and Lacey recommend the collection of fecal specimens rather than rectal swabs as

rectal swabs frequently yield very little or no fecal flora (1963, p.161). In addition to checking personnel, all infants and mothers in contact with the index case should be checked (Schroeder et al., 1968). Environmental culturing may be helpful in determining fomites responsible for perpetuating the spread (Mendis et al., 1976).

Patients who are known to be Salmonella excreters must be isolated from contact with other patients. In addition, all patients who develop diarrhea should be isolated until the cause of the diarrhea is known. Should a postpartum mother develop diarrhea, her infant should also be isolated. Patients with diagnosed Salmonellosis should be discharged at the earliest possible time to eliminate the potential spread from that particular source (Baine et al., 1973; Rowe et al., 1969; Schroeder et al., 1968). Staff caring for infected patients should have no contact with non-infected patients (Rice et al., 1976).

Due to the fluid nature of infants' stools, there is an increased risk of spread of infection by fecal contamination. Recommendations from the Public Health and Hospital Laboratories in the United Kingdon (1974) include using disposable diapers or boiling cloth diapers prior to laundering, and wearing disposable gloves when handling diapers. Precautions with other linens touching the infant should also be taken. Rowe et al. recommend

the use of separate staff for feeding infants and for diapering them (1969).

One of the most important considerations in halting outbreaks is enforcement of handwashing before and after handling each patient (Adler et al., 1970; Rowe et al., 1969; and Watt et al., 1958). Adler utilized an iodine-containing soap from a foot-operated dispenser. Watt emphasized the need for easily accessible wash basins in sufficient quantity "to cause the nurse the fewest possible steps" (1958, p.704). Soap and water washing has been shown to be as effective in removing pathogens from hands as 70% alcohol solutions (Infection Control Nurses Association, 1974). The manner in which hands are washed, though, is important. Taylor observed handwashing practices of 129 nurses using an alcohol soluble dye. The dominant hand was not cleansed as effectively as the other hand. In addition, thumbs, fingertips, and palmar creases were generally poorly washed (1978). Technique in handwashing needs to be stressed. Watt et al. during an outbreak cultured S. tennessee from a nurse's hands directly after she had washed them (1958). No comment was made on the manner in which she had washed.

"Isolation" in the articles reviewed appears to vary in definition. Several authors utilize this term as meaning the "geographic separation of infected from non-infected patients" (e.g., Ip et al., 1976) while others allude to incorporating

"enteric isolation" procedures (Adler et al., 1970). While isolating groups of infected patients, contacts of infected patients, and non-contacts from each other may be useful in stemming outbreaks on particular wards, enteric precautions are necessary to prevent spread to other parts of the hospital. Barrett-Connor states that "Enteric isolation is used for fecal-oral spread diseases; stool precautions, and strict handwashing are all that are really necessary, but many hospitals also utilize gown procedures to remind those attending to the patients of the potential risk" (1972, p.203). Stool isolation in infants can be problematic, as mentioned earlier, due to the fluid nature of infant feces. Adler et al. used the following control measures: wearing gloves and gown when handling infants in isolation; using disposable diapers; eliminating common play, feeding, and bathing areas; and discharging patients as soon as medically feasible. Common tubes of lubricating jelly were replaced by disposable packages, and new scales were purchased so that patients, contacts, and non-infected infants could be weighed separately (1970, p.972).

Although the practice of isolating the infant with the mother was not used in any of the Salmonella outbreaks reported above, it has been used effectively in slowing staphylococcal cross-infections (Krynski, Becla, and Kaminenska, 1973; Mortimer, Wolinsky, and Hines, 1963). Rooming-in of babies with their

mothers, rather than isolating the infants in a separate nursery has implications not only for curbing the spread of infection, but for maternal-infant bonding as well.

When the spread of infection threatened to become rampant, wards were closed to further admissions in many of the outbreak situations reported in the literature. Following discharge of the last infected patients, terminal cleaning of the rooms was carried out prior to re-opening the units (e.g., Adler et al., 1970; Mendis et al., 1976; Rowe et al., 1969). Rowe reports washing walls, ceilings, and floors three times with a bactericidal ampholytic surface-active agent; steam sterilizing bedding; destroying inexpensive articles; and fumigating incubators with formaldehyde and ammonia; and sterilizing electrical equipment with ethylene dioxide gas (1969, p.562). These procedures effectively terminated the outbreak.

Infection Control: Implications for Nursing

Hospital-acquired infections are beginning to account for an increasing proportion of infectious diseases. This has been influenced by the decline in primary infectious diseases in man with a concurrent stabilization of the rate of nosocomial infections (Riley, 1977). Interest in nosocomial infections heightened in the 1950's due to the emergence of hospital out-

breaks caused by resistant strains of <u>Staphylococcus aureus</u> subsequent to the abuse of antibiotics. While correction of the misuse of antibiotics assisted in solving this problem which caused havoc in nurseries as well as medical and surgical wards, a new problem emerged in the form of opportunistic infections caused principally by gram-negative bacilli and, more recently, fungi. Their prevalence in the hospital environment has been enhanced by their ability to thrive in most environments away from the human body, and to resist both disinfectants and many antibiotics. One other major factor has contributed to their supremacy: the increasing number of patients in hospital whose immune systems are compromised either by age, drug therapy, or disease (Selwyn, 1972). Heightened awareness of the potential dangers to patients listed above, led to the wide acceptance and organization of committees designed to control infections within hospitals (e.g., Sager and Rosenberger, 1958; May, 1958).

The composition of Infection Control Committees varies according to institution, but usually consists of representation from hospital administration, internal medicine, surgery, pediatrics, obstetrics, microbiology, and nursing with ad hoc representation from dietary, staff health, housekeeping, and pharmacy (American Hospital Association, 1974). LeRiche et al. recommended the inclusion of the Medical Officer of Health, the Director of Nursing Education, and a public health nurse (leRiche, Balcom,

and Van Belle, 1966). The responsibilities of the committee are basically the setting of standards; the development, implementation, and ongoing evaluation of programs and policies aimed at reducing hospital-acquired infections; and the recognition and control of nosocomial outbreaks should they occur (American Hospital Association, 1974). To implement the programs desired by the Infection Control Committee, several hospitals appointed infection control nurses (e.g., Davis, Fielding, and Garlick, 1963; Garner, 1962).

Chavigny, in a review of the literature on microbial infections in hospitals in 1977, points out that while the complex problem of the prevention and control of infection in hospitals requires the coordination and cooperation of all disciplines, "the major responsibility of infection control lies with the nursing profession - the only discipline which is committed to the 24-hour provision of care for the sick in hospitals" (p.37). Anderson and Himmelsbach provide a framework for examining nursing responsibilities by delegating the responsibilities to four nursing specialities: the nurse administrator, the nurse control officer, the nurse practitioner, and the public health nurse. The nurse administrator contributes to infection control by providing nursing input to the infection control committee, developing and implementing practices and procedures on her ward, and providing orientation on safe practices to new staff. These

include special emphasis on handwashing, aseptic techniques, safety procedures for handling contaminated equipment, and the need for health education of the patient and visitors. In addition, the nurse administrator is responsible for liaising with other groups and acts in an advisory capacity to "maintain morale and interest in infection control measures among nursing personnel - especially when differences in opinion arise, as between physicians and nurses" (1967, p.88).

The majority of articles in the literature which deal with the implications of infection control for nurses are concerned with the development of this relatively new area of nursing specialization. The infection control nurse (ICN) has a wide range of responsibilities which vary from institution to institution. Garner (1978) includes in the list of responsibilities "surveillance of nosocomial infections, analyzing and distributing surveillance data, investigating epidemics, assisting the Infection Control Committee in developing infection control policies, overseeing implementation of infection control policies, and day-to-day consultation and follow-through with nurses and physicians on infection control problems and questions ... Other consulting responsibilities involve providing consultation for in-service education and employee health service" (p.11). Hindley includes liaising with public health as an important function (1976). Parker (1976) sees the major functions of the

ICN as being research, advising, and teaching. LeRiche et al. include in the responsibilities teaching personnel at all levels, investigating outbreaks, recording and reporting of infections, supervising aseptic techniques, and leading campaigns aimed at infection control in the community at large (1967). Anderson and Himmelsbach view her as "'eyes' and 'ears' of the infection control committee" with responsibilities in the areas of "case finding, surveillance and reporting, analysis and interpretation, epidemic investigation, inspection, control, education, prevention, liaison, and program evaluation and recommendation" (1967, p.90).

While an infection control nurse can be an asset to an institution, not all hospitals employ one. The presence of an infection control committee is a requirement of the Canadian Council on Hospital Accreditation (CCHA): the employment of an ICN is not (Murray, 1975). The infection control committee is visited with the responsibility for controlling infections within the hospital and maintaining a safe environment by the CCHA. It is the practicing nurse, however, who is the "first line of defense against infections" for her patients (Anderson and Himmelsbach, 1967, p.84).

The nurse who is providing care at the bedside has received very little direct attention in the literature dealing with nosocomial infections. She is indirectly alluded to in several

of the hospital outbreaks discussed earlier as a disseminator of infection through failure to implement isolation techniques and failure to properly wash her hands (Adler et al., 1970; Lintz et al., 1976; Watt et al., 1958). Most authors feel that while nurses have the knowledge to apply good aseptic technique, they do not adequately utilize what they know. Cragg, in reference to nurses' responsibility in cross-infection situations, states that "there can be little doubt that the nurses' role is central in ensuring maintenance of good aseptic technique on a ward. Nurses know the correct procedures, and have the most frequent and direct contact with patients. They are responsible for teaching visitors the technique and for protecting their patients by reinforcing its use by other staff" (1979, p.41).

Cragg reports a study undertaken at the Hospital for Sick Children in Toronto to determine if an educational program would reduce rates of cross-infection on two pediatric wards. On the first ward where the program was imposed, little enthusiasm was generated, and the effect on infection rates was minimal. On the ward where the program was requested, the staff were willing to work and the improvement was noticeable. Cragg concludes that the difference can be accounted for by differing degrees of commitment (1979).

Anderson et al. emphasize that every staff member must be alert to signs which signal infection. The nurse, in addition to

charting her findings, must communicate the information to one in authority so that proper steps can be taken to avoid cross-infecting other patients (1967).

In commenting on some of the problems leading to nurses breaking technique during an outbreak of Salmonellosis, Watt et al. state: "Perhaps the most important lesson has to do with the problem of staffing and of defining duties and responsibilities for nursing staff. It is clearly unrealistic to lay out an elaborate plan for handwashing and other care techniques and then overload the staff so that it is physically impossible to do a first rate job. Not only does this defeat the stated purpose but the conflict between standards and actual performance produces frustration leading to further difficulty" (1958, p.704).

The fourth nursing specialty with a role to play in infection control is the public health nurse. Anderson and Himmelsbach see the public health nurse's role as providing follow-up care for the patient at home, health teaching for the family, and statistics for the Medical Officer of Health (1967). LeRiche et al. advocate the inclusion of the public health nurse on the hospital infection control committee to provide current information on the prevalence of communicable diseases in the community (1966). Public health nurses, however, play an important role in providing health care teaching to clients discharged with communicable diseases. They must ensure that there is no further

dissemination of the disease to the community at large.

Research Approaches

In this study, methods basic to the science of epidemiology have been utilized. Epidemiology is classically described as "the study of the distribution and determinants of disease frequencies in man" (MacMahon and Pugh, 1960, p.1). The population rather than the individual is the unit of analysis. Descriptive techniques are utilized in collecting information on the distribution of a disease in relation to various demographic variables such as age, sex, and locale. These data are then utilized in an attempt to determine causal factors of the illness within the population. Susser provides direction for MacMahon and Pugh's definition by adding that "these activities are for the purpose of the prevention, surveillance, and control of health disorders in populations" (1973, p.3).

The most common method of conducting research utilized in epidemiology is the survey method (Fox, Hall, and Elveback, 1970; Susser, 1973). The survey is a general method used to establish relationships between or among variables in a population in numerical terms. Three general approaches are used in epidemiology: description surveys, which set out the distribution of various characteristics of the population; analytic surveys,

which compare different populations to account for the variations between them; and experimental surveys, which control variables within the population and introduce a new element in order to measure its effect (Susser, 1973, p.7).

Descriptive or observational studies in a field setting comprise the bulk of epidemiologic research (Fox et al., 1970, p.269). Outbreak investigations are an example of descriptive studies. Most textbooks contribute lists of steps which are taken in investigating epidemics. Most authors include the following procedures:

1. Verify the diagnosis;
2. Establish the existence of an epidemic;
3. Inspect the environment;
4. Describe the epidemic in respect to the variables of person, place, and time by looking at
   (a) age, sex, ethnic origin, etc.,
   (b) spot maps (floor plan, city maps, etc.),
   (c) epidemic curve,
5. Formulate hypotheses of who is at risk by
   (a) identifying the type of epidemic, and
   (b) defining the population at risk;
6. Establish control measures to prevent spread;
7. Search for additional cases;
8. Conduct more detailed analysis by
   (a) calculating attack rate tables,
   (b) establishing laboratory confirmation, and
   (c) conducting environmental studies;

9. Evaluate earlier hypotheses;
10. Report investigation;
11. Institute long-term control measures.

(leRiche, and Milner, 1971; MacMahon and Pugh, 1970; White, 1976).

Analytic studies are more sophisticated but are usually undertaken to test hypotheses generated by observational studies. Two major approaches are utilized: retrospective surveys which compare patients with non-patients in terms of prior exposure to disease; and prospective studies (field surveys) in which the development of disease is observed in exposed and unexposed groups. These formats do not allow for the manipulation of variables (Fox, 1970).

Experimental surveys are rarely conducted in the epidemiology of acute diseases. The most common form of experimental survey conducted is the vaccine trial in which vaccine and placebo are given to two large groups of children respectively, and follow-up serological surveys are conducted to determine vaccine efficacy (Friedman, 1974).

Search for Causality

Disease is attributable to the interrelationships of multiple factors. With an infectious disease, the biological agent whether it be viral, bacterial, rickettsial or protozoal must be present for disease to occur. While the agent is necessary, by itself it is not sufficient to cause illness. Other factors in the host and in the environment must be present before infection will occur. This requirement is referred to as multiple causation or multifactorial etiology (Mausner and Bahn, 1974). The classification of factors into host, agent, and environmental categories is customary in introductory texts of epidemiology (e.g., Fox et al., 1970; leRiche and Milner, 1971; Mausner and Bahn, 1974). The concept of agent is expanded by Fox to include nutrition elements, exogeneus, and endogenous chemical agents, physiological factors, genetic factors, psychic factors, and physical factors as well as invading living parasites (1971, pp.36-44). LeRiche and Milner add accidents, instruments of war, and social factors to the list (1971). With biological agents, several characteristics of the agent alluded to in the earlier section on Salmonella Infections are known to influence the development of disease. These include the number of organisms required to cause infection (inocculum), the virulence of the organism, and its resistance to antibiotics.

Host characteristics influencing the development of disease include age, sex, race, socioeconomic status, occupation, and marital status (Mausner and Bahn, 1974). Other important characteristics include the general health state and immune status (Fox et al., 1971; leRiche and Milner, 1971). Environmental factors refer to geographical and climatic conditions, social considerations such as housing and population density, and biological factors such as the presence or absence of particular flora and fauna (Fox et al., 1971; leRiche and Milner, 1971; Mausner and Bahn, 1974).

Epidemiology, as stated above, is concerned with establishing causal associations among factors with a view to preventing disease occurrence. MacMahon and Pugh, in discussing causal relationships categorize specific factors in the following manner:

> A. Not statistically associated (independent)
> B. Statistically associated
>   1. Non-causally associated
>   2. Causally associated
>   a. Indirectly associated
>   b. Directly associated.
>
> (1970, p.18).

Statistical association refers to a higher proportion of people in a specific category exhibiting both factors. Causal associations are most often determined experimentally, although MacMahon and Pugh provide three considerations which can be usefully

applied to non-experimental studies in attempting to prove causality. Firstly, the proposed causal event must precede the supposed effect. Secondly, strong associations are most likely to be causal. Finally, they should be consonant with existing knowledge (MacMahon and Pugh, 1970, pp.20-21). Mausner and Bahn add that consistency of association and the degree to which the occurrence of one variable can be used to predict the occurrence of another (specificity) are also criteria which are important for judging the causal nature of relationships (1974, pp.101-102).

To represent the causal relationship among variables, the use of models has developed. Susser describes the uses of models as either predictive or representation. With a predictive model, the known relationships among variables can be utilized to extrapolate future trends. The most common use of these models is for planning purposes. Representational models are useful in organizing, mediating, and analyzing relationships into a more simplified form. The organizational function of a model is inherent in the synthesis of quantities of complex related factors into a simplified visual form. As well, the model may serve to mediate between either traditional and contempory viewpoints within a discipline or between allied but usually unrelated fields of endeavour. Analysis of models which describe differing causal sequences resulting in the same outcome is useful in locating current gaps in knowledge (1973, pp.32-34).

The early models utilized in epidemiology dealt with simplistic causal relationships (Susser, 1973, p.30). The triangle, frequently referred to in epidemiology literature, is one of the first used. It implies that each component - host, agent, environment - must be considered in explaining disease occurrence. Alterations in any component will either increase or decrease disease.

Later models which look more realistically at the interrelationships among variables are more general in scope and usually lack the precision required to explain causal relationships (Susser, 1973, p.30). Two further models frequently used to illustrate more complex relationships are the wheel model and the web of causation.

In the wheel model, factors influencing the development of disease are considered to be part of man (including his genetic core), or his physical, social or biological environment. The disease causing agent belongs in one of these categories (Mausner and Bahn, 1974, p.35). While this model more realistically represents man and the agent as interacting with the environment, the relationship among individual variables is still not clear.

The web of causation, proposed by MacMahon, Pugh, and Ipsen in 1960 looks at the interrelationships of multiple components associated with the development of symptomatology. Rather than attempting to arbitrarily classify factors as "host," "agent," or

"environmental" influences, each documented factor is simply connected representationally by a line to other related factors, thus forming a network or web of interrelationships (1960, pp.18-20).

Both the wheel and the web of causation are termed "ecological models" as they focus on interrelationships of all living things rather than those dealing specifically with states of human health (Mausner and Bahn, 1974; Susser, 1973). The term "ecological" is also used more loosely in the social sciences to distinguish group phenomena from individual phenomena (Susser, 1973, p.51ff). In model development, as in other areas of research design, attention must be paid to the level of organization under review. Either the model should be limited to one level or variables must be sought that link the levels (pp.48-63).

Summary of the Literature Review

Newborn infants, especially those born prematurely are very vulnerable to infection. It is not surprising, then, that when Salmonellae spp. are introduced into the environment, outbreaks of nosocomial infection can occur. The chance of infection occurring seems to be enhanced when the strain is new to the community, or when it is resistant to many antibiotics.

The liquid nature of infants' stools predisposes to gross environmental contamination which can serve as a reservoir to perpetuate the epidemic for several weeks or months. Fecal carriage of Salmonella spp. by nursery staff can also lead to propagation of the outbreak. Control measures centre around re-instituting stringent aseptic techniques when handling infected infants and their clothing, isolating those who are infected, decontaminating the environment, and carefully washing hands before and after handling infants or their equipment.

Diarrhea in infancy has been noted to affect subsequent growth patterns although usually in a transient fashion unless nutritional or socioeconomic conditions are unfavourable. Among the many other factors which influence growth during the first year of life diet, sex, and size at birth will have the most affect.

It is clear from the literature that preventing nosocomial infections and their sequellae is the responsibility of all who work in hospitals. Nurses, however, must accept primary responsibility as they are the only health care workers who are in 24-hour contact with the patients. Whether working at the bedside, in administration, or as an infection control specialist, nurses must strive to prevent nosocomial infections through the careful application of accepted practices of aseptic and isolation techniques.

CHAPTER III

METHODOLOGY

Research Design

It was stated in Chapter I that all aspects of this study - outbreak investigations, community survey to detect additional cases, and follow-up study of growth patterns in infected infants - were observational in nature. The non-experimental nature of the study precludes deliberate manipulation of the variables. This is consonant with the majority of studies undertaken in epidemiologic research (Fox et al., 1970).

For purposes of clarity in ensuing discussions, the methodological aspects of this study are divided into two phases: Phase I refers to all aspects of the outbreak analyses; Phase II refers to the study of growth patterns in infected infants. Phase I is further divided into the following sections: IA refers to the investigation of the initial outbreak, IB refers to the investigation of the second outbreak, and IC refers to the search for the occurrence of additional infections disseminated to the community between IA and IB.

In outbreak investigation, variables associated with the development of the disease are determined as the result of anal-

ysis of the data rather than prior to data collection. Studies of this nature are undertaken to enumerate cases with a view to elaborating the distribution of disease. The investigator chose, a priori, factors which in terms of the literature were logical priorities in data collection, and for which data existed. The factors which appeared to be associated with the development of Salmonellosis in infants became the independent variables in the more rigorous analyses aimed at determining factors predisposing to infection.

Independent Variables

In Phase I, the independent variables included: sex; length of hospitalization; mode of delivery; weight, length, and head circumference at birth; nursery utilized; diet; antibiotic usage; treatment with phototherapy; anoxia; and the relationship of size to gestational age. In addition, some maternal factors were considered, including age, marital status, parity, and socio-economic status.

In Phase II, all of the above independent variables were included in the analyses. In addition, the following variables were included: Salmonellal infection during the neonatal period; weight, length, and head circumference at three months; diet at three months; history of diarrheal illness prior to three months;

weight, length, and head circumference at six months; history of diarrheal illness between three and six months; weight and length at twelve months; and history of diarrheal illness between six and twelve months of age.

Dependent Variables

In Phase I, the dependent variable was infection with Salmonella california. In Phase II, the dependent variable was "growth."

The Patient Population

The total patient population studied in this report consisted of infants born in a large teaching hospital. The infants in Phase IA were cared for in the newborn nurseries of the hospital between July 18 and August 1, 1977 (N=111). In Phase IB, infants born in this hospital between January 27, 1978 and February 23, 1978 were included (N=219).

All newborn infants admitted to the Neonatal Intensive Care Unit (NICU) between August 1, 1977 and January 27, 1978 were included in Phase IC. There were 278 infants admitted to the NICU during the period of time under study. During the investigation, 183 (65.8%) of the infants had fecal specimens submitted for analysis.

For analysis of factors predisposing to infection and for the follow-up study of growth patterns in infected infants, all of the infants in Phases IA and IB who still lived in Edmonton and attended the Well Baby Clinics sponsored by the Edmonton Local Board of Health, were candidates for inclusion. Table 1 shows the proportion of infants located for follow-up using this method.

TABLE 1

STUDY POPULATION FOR PHASE II

Outbreak	Number of Infants Born	Number of Infants Attending City Clinics	Proportion of Infants Eligible For Study
July 18 - August 1, 1977	111	48	43.2
January 27 - February 23, 1978	219	100	45.7

A substantial proportion of the population served by the hospital is rural. The decision was made not to include these babies in follow-up. Due to both the exclusion of rural children and the mobility of families in the city population, the many infants were lost to follow-up.

Infants with congenital or developmental problems which could potentially influence their rates of growth were excluded from Phase II of the study. These included: congenital heart

disease (2); identified psychomotor abnormalities (2); and cleft lip and palate (1). Other infants whose records at the Well Baby Clinics did not include at least three serial measurements of weight, length, and head circumference were also excluded. Of the 148 who could be located, 97 infants, with measurements of weight, length, and head circumference at three, six, and twelve months of age were included. A further 13 were included with measurements available only up to six months of age, making for a total of 110.

Research Instrument

A questionnaire was constructed to obtain information about infants' stool characteristics, antibiotics administered, and patterns of illness in Phase IC. It was designed for data collection from parents by public health nurses. The questionnaire consisted of a series of closed questions designed to elicit information about the infants' bowel habits.

Questions on stool characteristics were designed following an analysis of the descriptions of infected infants' stools contained in the nurses' notes during the first outbreak. The assumption was made that these would be the differences that would be most readily noticed by the mother or guardian. In addition, the parent/guardian was asked if the child had had any episodes

of frequent loose stools, or if the child had had diarrhea. The use of antibiotics was also questioned. A copy of the instrument is contained in Appendix II.

Validity

The instrument was examined by three physicians with expertise in infectious diseases, the Research Officer of the Edmonton Local Board of Health, and the eight Nursing Supervisors of the public health clinics in Edmonton. Only items on which there was majority agreement were included in the questionnaire. This provided some degree of content validation (Campbell and Stanley, 1974).

In addition, culturing rectal swabs to determine the presence of *Salmonella spp*. provided a measure of concurrent validity for the instrument's ability to detect Salmonellal infection (see Campbell and Stanley, 1974).

Reliability

No testing for reliability of the instrument was carried out prior to administering it.

Data Collection Procedures

Outbreak Investigations

During both outbreaks, the investigator, as Nurse Epidemiologist with the Edmonton Local Board of Health, was invited to participate in analyzing the problem. In both instances, the outbreaks had peaked prior to the issuance of the invitation. Line listings of all infants known to be infected were created from existing hospital records containing information on all factors judged by the investigator to be pertinent and for which data existed. The information included nursery utilized, mode of delivery, birth date, sex, birth weight, use of suction equipment, use of oxygen equipment, antibiotic therapy, other treatments, diet, symptoms of illness, and the treatment of the Salmonella infection. Information collected on each infant's mother included her address, hospital room number, parity, marital status, and symptomotology on admission and throughout her hospitalization. Information on all other infants born during the outbreak periods was then collected according to the categories listed above.

Concurrently, environmental swabbing was done of all equipment, isolettes, cribs, furniture, and delivery tables. Unfortunately, a decision was made in Phase IA to delay environmental

swabbing until after terminal cleaning of the wards had been carried out. All staff were required to submit stool specimens for culturing. All infants in the nurseries and their mothers had stool specimens sent for culture prior to discharge. Samples of formula chosen from the same lot used during the outbreak were submitted for culturing. Records of positive cultures and antibiotic sensitivity patterns were obtained from the Provincial Laboratory of Public Health.

At a later date, information on gestational age, length at birth, and head circumference at birth was collected on all infants to be included in the Phase II study, from their hospital records. Information on maternal parity, and the occupation of either the mother or father was also noted.

For 9 months following the second outbreak, all newborns had stool cultures taken on their fifth day of life or at discharge, which ever came first, to check for further dissemination of the organism.

Community Survey

Lists of infants who had been admitted to the NICU were obtained from the hospital understudy. Birth dates and the parents' addresses at the time of birth were obtained from the hospital's admission lists. Infants were grouped by address into

groups corresponding to the Regions served by the eight City health clinics. Infants residing out of town were grouped according to the Provincial health unit areas.

Public health nurses attempted to visit each infant at home. After explaining the reason for the visit, the nurse administered the questionnaire to the parent or guardian and then obtained a fecal specimen by rectal swab, or from stool, if available. The fecal specimens were taken to the Provincial Laboratory of Public Health for culturing. Questionnaires were returned to the central office of the Edmonton Local Board of Health.

When no one was available at the address, the nurse left a letter explaining the nature of her visit and asking the parent to call. If these parents were unavailable during the day, the questionnaire and instructions for collecting the stool specimens were then left at the home.

For infants residing out of town (N=75) lists of the infants' names, birth dates, and addresses were forwarded to the Medical Officers of Health (MOH's) for the appropriate districts. An explanation of the study, and sufficient copies of the questionnaire accompanied the lists. In addition, the Deputy Medical Officer of Health for the City of Edmonton called the outlying MOH's to further apprise them of the study, and request their support. Public health nurses from these districts then visited the infants at home to administer the questionnaire and collect

the fecal specimens. The rate of recovery from the districts was 64%. Within the city, a recovery rate of 66.5% was obtained.

Study of Growth Patterns

To obtain the measurements of diet, illness, weight, length, and head circumference, records of the City health department were used. The intervals of 3 months, 6 months, and 12 months were chosen as they corresponded with existing schedules for immunization. If infants had been assessed as being pre-term at birth, adjustments in the dates chosen for measurements were made in accordance with recommendations by Lubchenko et al. (1966). Measurements taken within one week on either side of the chosen intervals were accepted without modification. All measurements were converted to metric.

If infants visited the clinic at intervals other than those specified above, the required measurements were calculated by methods utilized in Newman and Alpaugh (1976). Available measurements were plotted on a growth graph. A linear relationship between the measurements was assumed, and a straight line drawn to connect them. The point at which this line intersected the desired time interval was chosen as the infant's measurement for the required time. To use this approach, a measurement had to be available within two months of the required time. No attempt was

made to project measurements beyond the data available. If an actual measurement had not been obtained on either side of the required one, no measurement was recorded. Assessments of head circumference were not routinely recorded for infants at 12 months of age. This measurement was dropped from the analyses.

Socioeconomic status of families was established using the scale for fathers' occupations published by Blishen and McRoberts in 1976. The index scores were divided into three classes based on methods suggested by Blishen (1967). If the mother was unmarried, her occupation was used to determine the SES of the family by utilizing the scale published by Blishen and Carroll in 1978. If the head of the household was unemployed or was a student, the family was not classified.

Children were assessed as being small for gestational age if their birth weight was below the 10th percentile on the graph developed by Lubchenko et al. in 1966.

Analysis of the Data

The analysis of the data is described as follows: outbreak analysis procedures (Phases IA and B); analysis of the community survey (Phase IC); and growth analysis procedures (Phase II).

Outbreak Analysis Procedures

Epidemic curves for outbreak analysis were plotted for both outbreaks. The place where greatest transmission occurred was determined by tabulating the distribution of uses by nursery of residence during the outbreak. Babies at risk were characterized by tabulating the distribution of cases by birth date, sex, mode of delivery, diet, and treatment regime.

To determine associations between independent and dependent variables, infants who acquired S. california during the neonatal period were compared to their non-infected birth cohorts on the independent variables using Chi Square analysis. Data which were interval or ratio scale were converted to ordinal categories for the procedure (Ferguson, 1971).

Step-wise discriminant analysis was used to determine which independent variables exerted the most influence on the development of the disease (Kerlinger, 1973). Because the technique is based upon correlations, an assumption had to be made that the variables were quantitative in nature (interval or ratio scale) (Ferguson, 1971). To meet this criterion, data which were nominal or ordinal level were converted by using dummy variables (Kim and Kohout, 1975).

Community Survey

Information from the survey was summarized and arranged in frequency tables.

Analysis of Growth Patterns

Step-wise multiple regression analysis was performed to determine the amount of variance accounted for in growth by the independent variables. Several measurements of growth were used. For the purposes of this study, "growth" was defined as the increase in anthropormorphic measurement between two specified time intervals. Growth in weight was determined for 0 to 3 months, 3 to 6 months, 6 to 12 months, and 0 to 12 months; linear growth was determined for 0 to 3 months, 3 to 6 months, 6 to 12 months, and 0 to 12 months; growth in head circumference was determined for 0 to 3 months and 3 to 6 months.

Two basic assumptions underlie the use of regression analysis. Firstly, the variables were assumed to be additive (interval or ratio level). This assumption was met by converting nominal and ordinal level data to dummy variables. The second assumption was that the relationship between the independent and dependent variables is linear (Kerlinger, 1973).

As growth patterns are known to be curvilinear, an attempt was made to straighten the line by converting anthropormorphic measurements to logarithmic scales. A better approximation of linearity, as judged by plotting residual score during multiple regression analysis, was maintained by using the actual measurements. The logarithmic conversions were not used in further analyses.

CHAPTER IV

PRESENTATION AND ANALYSIS OF THE DATA

The data relevant to Phase I of the study are presented and analyzed in the following order: (1) description of the outbreaks; (2) comparison of results obtained in both outbreak investigations; (3) results of the community survey; and (4) results of the study of predisposing factors. The analyses of data relative to the independent variables under discussion in Phase II of the study are presented in the following order: (1) factors affecting growth as measured by weight gain; (2) factors affecting growth as measured by increase in body length; and (3) factors affecting growth as measured by an increase in head circumference.

Outbreak Investigations

Description of the First Outbreak

On July 21, 1977, Baby A (BD. 18-7-77), a patient in the NICU of a large city hospital was noted by her nurse to have watery-green stools. A stool culture was obtained, but the infant was not isolated until the laboratory provided a diagnosis

of Salmonellosis two days later. On July 23rd, the infant was started on a 10-day course of gentamycin therapy. A stool specimen collected from the mother revealed the presence of Salmonella spp. The sero-type of both cultures was later reported to be S. california. Examination of Mrs. A's hospital chart revealed that although she had not had any diarrhea prior to or following delivery, she had felt unwell for 24 hours. Her admission temperature was 38.3°C.

On July 26th, Baby B (BD. 6-7-77) developed loose, mucoid, blood-streaked stools. His temperature rose to 39°C. Isolation techniques were instituted, including gowning when handling the infant, and handwashing after touching either the infant, his clothing, or equipment used to care for him. He was also started on a 3-day course of anpicillin and kanamycin therapy. On July 28th, when the infant was confirmed by the lab as having Salmonellosis, three other infants, Baby C (BD. 26-7-77), Baby D (BD. 18-7-77), and Baby E (BD. 20-6-77), being cared for in the same end of the neonatal nursery as Babies A and B, had stools cultured. Although the infants were asymptomatic at the time of culturing, all of them later developed loose stools.

Baby F (BD. 23-7-77), transferred to NICU for phototherapy on July 24th, developed frequent bloody, mucoid stools on July 27th. While a 5-day course of gentamycin therapy was started then, isolation procedures were delayed until positive culture

reports were received on July 29th.

Baby G (BD. 26-7-77) was transferred from NICU to the main nursery on July 27th. He was readmitted to NICU on July 28th, when he developed loose stools, and was isolated on July 31st when Salmonellosis was confirmed. Baby H (BD. 25-7-77), who had been in the NICU following birth, had stools cultured following discharge by a public health nurse and was also found to have Salmonellae in his stool. The Provincial Laboratory of Public Health later confirmed that all of the above Salmonella isolates were S. california. One other infant with watery stools was shown to have S. typhimurium; no further isolates of this serotype were detected. The stools of two further mothers, Mrs. G and Mrs. H, were found to be positive on later cultures taken after discharge.

Control Measures

On July 30th, all admissions to the nurseries and obstetrical floor were stopped. All infants and mothers still in hospital were cultured. Those with negative stool cultures were discharged as quickly as possible. All infants suspected of having diarrhea were kept in an observation nursery. A temporary nursery was opened on the obstetrical floor to care for infants not ready for discharge. Babies already in NICU stayed there until

discharged home. Visiting was restricted.

Infants with Salmonellosis, and infants with loose stools were placed on isolation technique. Contacts of these infants were nursed separately, but were not on isolation protocol. Separate nursing staff was used for each category of infants.

On August 3rd, the last patients on the obstetrical floor were discharged, and both the labour and delivery suite, and the obstetrical floor were thoroughly cleaned. Admissions were again received on August 4th.

The NICU remained closed to admissions until the last infant was discharged home on August 6th. All of the nurseries were disinfected prior to reopening and environmental cultures were taken. All patients discharged from the nurseries and obstetrical floor who had not been cultured were investigated at home by public health nurses.

Description of the Second Outbreak

On January 27, 1978, Baby A2 (BD. 25-1-78) developed watery-green stools. A specimen was taken for culture, and the infant was placed on isolation technique in one corner of the normal newborn nursery until a report of Salmonellal infection was received. At this point, the infant was placed on isolation

technique in the same room as his mother who was culture negative. Both were discharged home on January 31.

On February 3rd, Baby B2 (BD. 1-29-78) developed loose green stools. While the "looseness" disappeared a few days later, the stools became offensive-smelling by February 9th. On February 10th, the stools were cultured and on February 14th, the laboratory confirmed a Salmonellal infection. At that point, the baby was isolated from other infants in NICU. A stool culture screening on all infants was conducted.

Baby C2 (BD. 2-2-78) had been documented in the nursery notes as having loose greenish/yellow stools on February 4th. By February 12th, blood was noted in his stool, and a culture was taken. He was placed on isolation technique on the 13th. Positive reports were received from the laboratory February 16th on a second specimen taken on the 14th.

Baby D2 (BD. 30-1-78) and Baby E2 (BD. 1-2-78) were found to be harbouring Salmonellae following the stool screening. Both infants had been in NICU following delivery. Baby D2 did not have loose stools, but developed a red rash on her butt, as had Baby C2. Baby E2 had loose watery stools intermittently between February 4th and 7th, although the cultures were not obtained until the 14th.

All isolates were again identified as S. california. This sero-type was sensitive to all major antibiotic groups, as had been the case in the first outbreak.

Control Measures

No attempt was made to close either the obstetrical floor or the NICU. Rather than separate the infants from their mothers, isolation procedures were drawn up by hospital personnel to allow the pair to be together (Appendix C). Visiting in the room was restricted to fathers only. Both parents were instructed in the handling of the contaminated equipment. Long-sleeved gowns were to be worn when handling the infant. While the normal procedure in the hospital was to return infants to the nursery at night for closer observation, infected infants were to remain with their mothers for the entire 24 hours. Nurses were instructed to take the initiative in isolating infants with diarrhea. Each unit was to be thoroughly cleaned when the pair was discharged. Guidelines for the care of infants in the NICU were also clarified (Appendix C).

Extensive environmental culturing was carried out on equipment from the labour and delivery rooms, and the nurseries, with special attention being focused on suction equipment and tubing, oxygen equipment, and anesthetic equipment.

Results of Outbreak Analyses

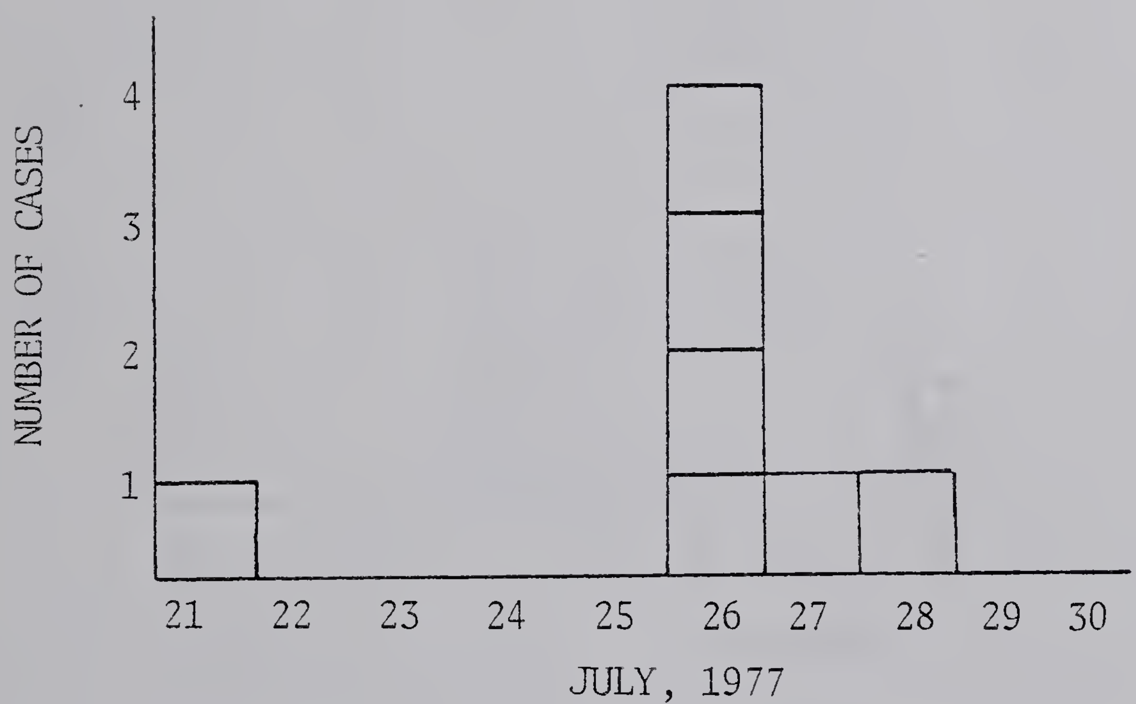
Figure 1 illustrates the temporal relationship among cases in the nursery during the first outbreak by date of onset of symptoms. The histogram indicates the outbreak is more in line with a propagated than a common source outbreak. The clustering of cases around July 26th and 27th could have resulted from exposure to a common vehicle at that point in time, however. In Figure 2, the relationship among the cases during the second incident definitely assumes the shape of a propagated outbreak. Baby A2, the index case of the outbreak had been discharged by the time baby B2, the second case, became ill. In addition, both the index and last cases were in the normal nursery rather than NICU. Closure of the ward during the first outbreak is the most probable cause of a shorter epidemic period at that time.

In Table 2, comparison of Attack Rates between the outbreaks indicates that proportionally fewer infants were involved during the second outbreak. While only the NICU was involved during the initial outbreak, cases occurred in the normal nursery during the second outbreak.

The male:female ratio among cases in both outbreaks was 1:1 regardless of the fact that there were proportionally more males than females in NICU, the area of greatest risk of infection. During the first outbreak, the male:female ratio in NICU was

FIGURE 1

EPIDEMIC CURVE FOR INFANTS IN FIRST OUTBREAK
WHOSE ILLNESS WAS DETECTED IN HOSPITAL*

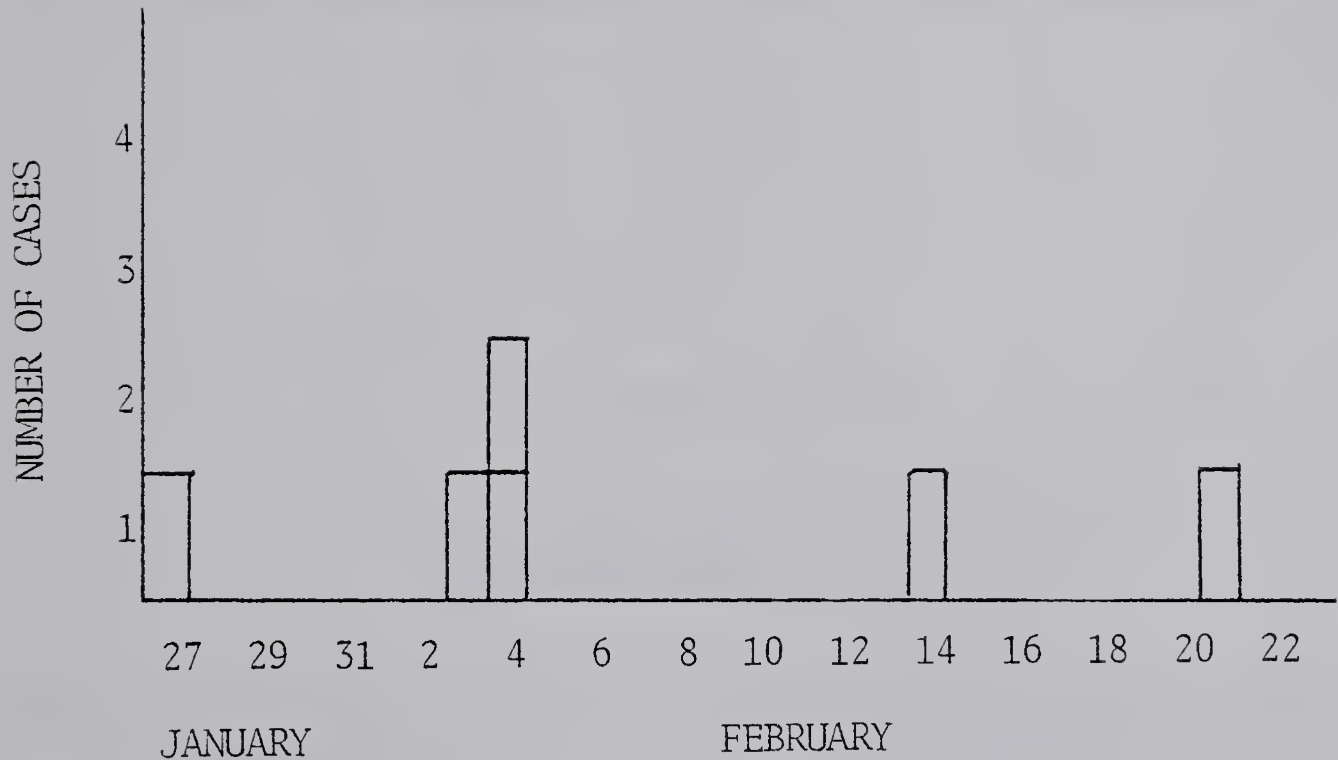


DATE OF ONSET OF SYMPTOMS, OR
FIRST POSITIVE CULTURE

* One infant, born July 25, who had been in NICU, was found to have positive stool cultures after discharge.

FIGURE 2

EPIDEMIC CURVE FOR INFANTS
IN THE SECOND OUTBREAK



DATE OF ONSET OF SYMPTOMS, OR
FIRST POSITIVE CULTURE

TABLE 2

COMPARISON OF ATTACK RATES BY NURSERY

Outbreaks	All Newborns	NICU	Normal Nursery
First (N=111)	5.4%	36.4%	0%
Second (N=212)	2.9%	6.7%	1.35%

TABLE 3

ATTACK RATES AMONG INFANTS
RECEIVING PHOTOTHERAPY

First Outbreak (N=6)	Second Outbreak (N=15)
66.6%	13.3%

1.75:1; during the second outbreak the male:female ratio was 1.06:1.

Phototherapy treatment reflected an association with the development of S. california (Table 3). In both outbreaks, attack rates were higher for infants receiving phototherapy than for those who did not.

The food specific attack rate analyses, Tables 4 and 5, do not implicate any particular diet as contributing to the development of Salmonellosis. No large discrepancy was noted between attack rates for bottle-fed versus breast-fed infants. Samples of formulae from the same lot as that used during the initial outbreak did not grow pathogenic bacteria on culture.

A total of six infants in the outbreaks was reported to be asymptomatic by the nursing staff. Recorded stool characteristics, however, indicated that there were differences detectable in most infected infants. The symptomatology was varied. Table 6 compares the proportion of symptomatic infants with their non-infected birth cohorts in NICU. Vomiting was not a prominent feature of the illness, but occurred more commonly in the infected infants. Fever was a symptom only during the first outbreak. Loose stools were also noted more commonly among infected infants, although they occurred in uninfected infants as well. Blood and mucous in stools were almost exclusively related Salmonellal infections. While colour was not very effective in

TABLE 4

FOOD SPECIFIC ATTACK RATES FOR INFANTS BORN DURING THE FIRST OUTBREAK

Food	Ate			Did Not Eat			Difference
	Ill	Total	Attack Rate	Ill	Total	Attack Rate	
Breast Milk	6	60	10.0%	2	51	7.8%	2.2%
Enfalac 13	0	14	0.0%	8	97	8.2%	-8.2%
Enfalac 20	7	66	9.4%	1	55	1.8%	7.6%
Glucose	8	106	13.2%	0	5	0.0%	13.2%

TABLE 5

FOOD SPECIFIC ATTACK RATES FOR INFANTS BORN DURING THE SECOND OUTBREAK

Food	Ate			Did Not Eat			Difference
	Ill	Total	Attack Rate	Ill	Total	Attack Rate	
Breast Milk	2	129	1.6%	4	90	4.4%	-2.8%
Prosobee	0	2	0.0%	6	219	0.0%	-2.7%
Enfalac 20	4	128	3.3%	2	91	2.2%	1.1%
Glucose	6	215	0.5%	0	4	0.0%	0.5%

TABLE 6

SIGNS AND SYMPTOMS EXPRESSED AS PERCENT AMONG CASES AND NICU PATIENTS

Signs and Symptoms	First Outbreak		Second Outbreak	
	Cases (N=8)	Contacts (N=25)	Cases (N=6)	Contacts (N=56)
1. Vomiting	25	12	33	5
2. Fever (37.5)	25	4	0	0
3. Loose Stools	88	52	83	20
a) Mucoid	88	12	50	2
b) Bloody	57	4	33	0
c) Greenish	88	36	83	9
d) Yellowish	88	44	83	18
4. Rash on Butt	50	12	33	0

distinguishing between the groups, greenish stools were more prevalent in the infected group. A buttock rash was also more common in infected infants.

In the first outbreak, three infants received antibiotic therapy for their infection and four infants required intravenous fluid therapy. In the second outbreak, the illness appeared to be less severe, and no specific treatment was required for any of the infected infants.

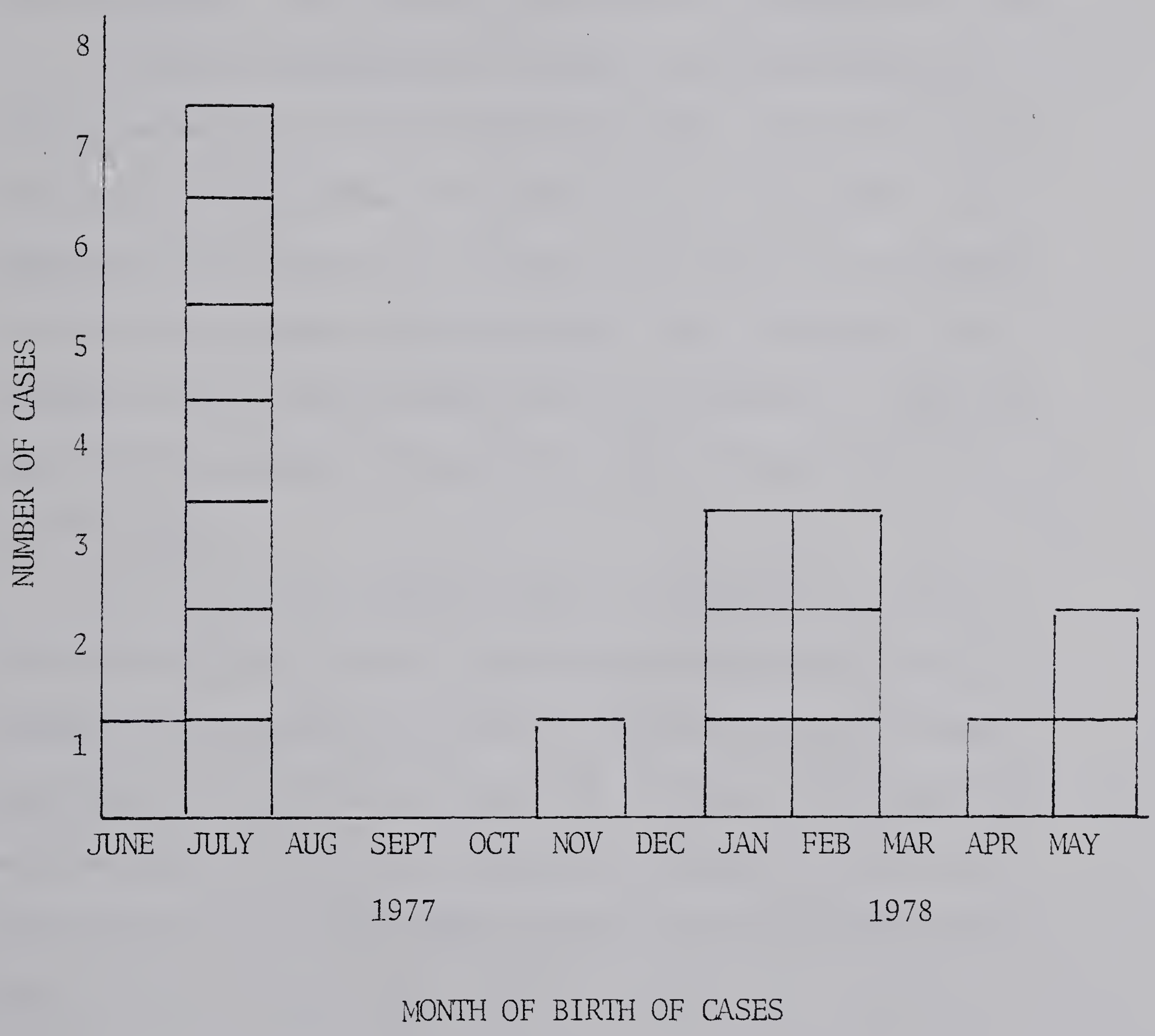
None of the environmental cultures revealed Salmonellal contamination. In addition, none of the stool samples submitted by nursing, medical, laboratory, housekeeping, or maintenance staff contained Salmonellae. The prospective stool screening of all newborns instituted following the second outbreak, however, revealed an additional three cases. One infant was born in April, and two were born in May (Figure 3). All of the infants were in the NICU, and two received phototherapy. Although the screening program continued until September, 1978, no further cases were revealed.

Community Survey

The stool screening survey revealed only one additional case of S. california. The infant had been in NICU between November 17th and December 29th. He had been discharged three weeks

FIGURE 3

TEMPORAL DISTRIBUTION OF CASES BY
MONTH OF BIRTH



before the index case of the second outbreak was born. His mother had not noted any abnormal stool characteristics. Two other cases of Salmonellosis were detected with species other than _california_. Both of these infants' mothers indicated on the questionnaire that their children had had increased, watery-green bowel movements. Both mothers noted mucous, and one noted blood.

If indeed _S. california_ was being disseminated from the nursery between the two documented outbreaks, two major factors would have influenced the low yield of additional cases: (1) length of time between birth and the collection of the specimen (2 to 10 months elapsed between exposure and culturing); and (2) the use of rectal swabs rather than fecal specimens. Edgar and Lacey (1963) indicate the superiority of stool specimens for fecal culture.

Due to the small number of cases found during the survey, the questionnaire's utility cannot be assessed definitively. However, the abnormalities chosen as characteristic of Salmonellal infection were found by parents as commonly in infants who were not considered to have increased stooling as in those who were considered to have either diarrhea, increased bowel movements, or both (Table 7).

TABLE 7

FREQUENCY OF RESPONSES TO QUESTIONNAIRE ON STOOL CHARACTERISTICS BY INDICATION OF ILLNESS

Stool Characteristics	Increased Bowel Movements	Diarrhea	Diarrhea and Increased Bowel Movements	Neither
1. No Abnormal Characteristics Checked	13	6	1	81
2. Abnormalities	12	4	9	50
a) Watery Green	6	0	3	22
b) Blood	2	0	0	7
c) Mucous	0	0	2	12
d) Watery Green and Blood	1	1	1	1
e) Watery Green and Mucous	2	1	1	6
f) Blood and Mucous	0	1	0	1
g) WG, Blood and Mucous	1	1	2	1
TOTAL	25	10	10	131

Length of Carrier State

Information on the infants' duration of excretion of Salmonellae based on laboratory results from the Provincial Laboratory of Public Health is provided in Table 8. The length of carriage was not significantly increased by the use of antibiotics in hospital during the neonatal period (Table 9).

Study of Predisposing Factors

The independent variables chosen for inclusion in the further analyses to determine factors predisposing to infection included length of hospitalization; mode of delivery; weight, length, and head circumference at birth; nursery; diet; antibiotic therapy; phototherapy; anoxia; relative gestational size; gestational age; and maternal age, parity, SES, and marital status. The results of Chi Square analyses indicate that statistically significant differences ($p < 0.05$) exist between the infected and non-infected groups in relation to the following variables: phototherapy (Table 10); length of hospitalization (Table 11); SGA (Table 12); anoxia at birth (Table 13); breast-feeding (Table 14); formula feeding (Table 15); antibiotic therapy (Table 16); length of gestation (Table 17); birth weight (Table 18); birth length (Table 19); head circumference at birth (Table 20); and nursery utilized (Table 21). No differences were

TABLE 8

DURATION OF CARRIER STATE WITH
SALMONELLA CALIFORNIA

Infant	Birthdate	Date of First Positive Culture	Date of Last Positive Culture	Duration of Excretion (Months)
A1	18 July 77	21 July 77	9 March 78	9.5
B1	6 July 77	21 July 77	1 March 78	9.5
C1	18 July 77	27 July 77	26 Jan 78	6.0
D1	26 July 77	27 July 77	30 Nov 78	16.0
E1	20 June 77	27 July 77	27 July 77	0.0
F1	26 July 77	27 July 77	7 Sept 77	1.5
G1	23 July 77	29 July 77	18 Aug 77	1.0
H1	25 July 77	8 Aug 77	3 Nov 77	3.0
A2	25 Jan 78	30 Jan 78	12 Dec 78	11.5
B2	29 Jan 78	15 Feb 78	12 Sept 78	7.0
C2	2 Feb 78	17 Feb 78	27 Feb 78	0.5
D2	30 Jan 78	14 Feb 78	6 June 78	4.0
E2	1 Feb 78	14 Feb 78	3 March 78	0.5
F2	19 Feb 78	20 Feb 78	27 May 78	3.0
A3*	12 Nov 77	27 May 78	27 May 78	***
A4**	6 Apr 78	17 April 78	27 Nov 78	7.0
A5**	3 May 78	7 May 78	22 Nov 78	6.5
A6**	9 May 78	14 May 78	11 Nov 78	6.0

* Infant harbouring S. california during community survey.

** Infant noted to be harbouring S. california during on-going surveillance.

*** Date of infection not known.

TABLE 9

EFFECTS OF ANTIBIOTIC USAGE IN THE NEONATAL PERIOD
ON DURATION OF EXCRETION OF SALMONELLAE

Category	Range (Months)	Mean Duration (Months)
Antibiotics (N=5)	1 - 9.5	5.5
No Antibiotics (N=12)	0 - 16.0	5.2

TABLE 10

INFLUENCE OF PHOTOTHERAPY ON THE
DEVELOPMENT OF SALMONELLOSIS

Status	Treated (N=11)	Not Treated (N=112)
Infected	45.5%	12.5%
Non-Infected	54.5%	87.5%

$\chi^2_{1df} = 8.328$ $\quad$ $p = 0.004$

TABLE 11

INFLUENCE OF LENGTH OF HOSPITALIZATION ON THE DEVELOPMENT OF SALMONELLOSIS

Status	Under 4 Days (N=41)	5 to 8 Days (N=68)	9 Days and Over (N=14)
Infected	4.9%	5.9%	92.8%
Non-Infected	95.1%	94.1%	7.2%

$\chi^2_{2df} = 72.543$ $p = 0.000$

TABLE 12

INFLUENCE OF LOW BIRTH WEIGHT ON THE DEVELOPMENT OF SALMONELLOSIS

Status	SGA (N=11)	Within Normal Limits (N=112)
Infected	45.5%	12.5%
Non-Infected	54.5%	87.5%

$\chi^2_{1df} = 8.328$ $p = 0.004$

TABLE 13

INFLUENCE OF ANOXIA AT BIRTH IN THE DEVELOPMENT OF SALMONELLOSIS

Status	None (N=91)	Slight (N=9)	Moderate (N=6)	Severe (N=9)
Infected	12.1%	11.1%	50.0%	33.3%
Non-Infected	87.9%	88.9%	50.0%	66.7%

$\chi^2_{3df} = 8.657$ $p = 0.034$

TABLE 14

INFLUENCE OF BREAST FEEDING ON THE DEVELOPMENT OF SALMONELLOSIS

Status	Breast Milk Given (N=73)	No Breast Milk Given (N=50)
Infected	9.6%	24%
Non-Infected	90.4%	76%

$\chi^2_{1df} = 4.718$ $p = 0.030$

TABLE 15

INFLUENCE OF FORMULA FEEDING ON THE DEVELOPMENT OF SALMONELLOSIS

Status	Formula Given (N=77)	No Formula Given (N=46)
Infected	23.4%	2.2%
Non-Infected	76.6%	97.8%

$\chi^2_{1df} = 0.0016$ $p = 0.002$

TABLE 16

INFLUENCE OF ANTIBIOTIC THERAPY ON THE DEVELOPMENT OF SALMONELLOSIS

Status	Antibiotics Given (N=10)	Antibiotics Not Given (N=114)
Infected	60%	11.5%
Non-Infected	40%	88.5%

$\chi^2_{1df} = 16.542$ $p = 0.000$

TABLE 17

INFLUENCE OF GESTATIONAL AGE ON THE
DEVELOPMENT OF SALMONELLOSIS

Status	36 Weeks	37-38 Weeks	39-40 Weeks	41 Weeks
Infected	61.5%	12.9%	6.8%	15.0%
Non-Infected	38.5%	87.1%	93.2%	85.0%

$\chi^2_{3df} = 26.22$ $p = 0.000$

TABLE 18

INFLUENCE OF BIRTH WEIGHT ON THE DEVELOPMENT OF SALMONELLOSIS

Status	Under 2.6 Kg	2.7-2.9 Kg	2.0-3.2 Kg	3.3-3.5 Kg	3.6-3.8 Kg	3.9-4.1 Kg	4.2 Kg+
Infected	71.4%	11.8%	11.1%	6.9%	0.0%	11.1%	14.3%
Non-Infected	28.6%	88.2%	88.9%	93.1%	100.0%	88.9%	85.7%

$\chi^2_{6df} = 39.571$ $p = 0.000$

TABLE 19

INFLUENCE OF LENGTH AT BIRTH ON THE DEVELOPMENT OF SALMONELLOSIS

Status	Under 47cm	47-48cm	49-50cm	51-52cm	53cm+
Infected	60.0%	66.7%	6.3%	2.9%	10.5%
Non-Infected	40.0%	33.3%	93.8%	97.1%	87.5%

$\chi^2_{4df} = 40.123$ $p = 0.000$

TABLE 20

INFLUENCE OF HEAD CIRCUMFERENCE AT BIRTH ON THE DEVELOPMENT OF SALMONELLOSIS

Status	Under 33cm	33-34cm	35-36cm	Over 36cm
Infected	58.3%	16.7%	5.7%	12.5%
Non-Infected	41.7%	83.3%	94.3%	87.5%

$\chi^2_{3df} = 20.939$ $p = 0.000$

TABLE 21

INFLUENCE OF NURSERY PLACEMENT ON THE DEVELOPMENT OF SALMONELLOSIS

Status	NICU	Normal Nursery
Infected	38.6%	2.5%
Non-Infected	61.4%	97.5%

$\chi^2_{1df} = 25.508$ $\quad$ $p = 0.000$

observed for mode of delivery (Table 22); maternal parity (Table 23); age (Table 24); marital status (Table 25); or SES (Table 26).

Following the conversion of nominal and ordinal scale data to interval scale by the creation of dummy variables, the independent variables were subjected to discriminant analysis procedures. All of the variables which had an F-ratio statistically significant at the 0.05 level of significance (Table 27) were included in the step-wise analysis procedures. Table 28 details the steps included during the analysis procedures. Six variables remained at the conclusion of the analytical procedure. These included: length of hospitalization; NICU; formula-feeding; birth weight; phototherapy; Caesarian-section; and head circumference at birth.

The variable chosen as the best predictor of the development of Salmonellosis in these outbreaks was length of hospitalization. Using the canonical discriminant function, 95% of the cases could be predicted from this one variable (Table 29).

TABLE 22

INFLUENCE OF MODE OF DELIVERY ON THE DEVELOPMENT OF SALMONELLOSIS

Status	Vaginal Delivery N=77	Low Forceps N=21	Mid or High Forceps N=6	Breech N=4	Caesarian Section N=15
Infected	11.7%	9.5%	16.7%	25.0%	40.0%
Non-Infected	88.3%	90.5%	83.3%	75.0%	60.0%

$\chi^2_{4df} = 8.607$ $p = 0.0717$

TABLE 23

EFFECTS OF MATERNAL PARITY ON THE
DEVELOPMENT OF SALMONELLOSIS

Status	1(N=55)	2(N=44)	3(N=19)	4(N-2)	5(N=1)	6(N=2)
Infected	16.4%	15.9%	15.8%	0.0%	0.0%	0.0%
Non-Infected	83.6%	84.1%	84.2%	100.0%	100.0%	100.0%

$\chi^2_{5df} = 0.956$ $p = 0.966$

TABLE 24

EFFECTS OF MATERNAL AGE ON THE
DEVELOPMENT OF SALMONELLOSIS

Status	Under 16 Years (N=1)	17-19 (N=10)	20-24 (N=34)	25-29 (N=47)	30-34 (N=20)	35 and Over (N=11)
Infected	0.0%	20%	17.6%	19.1%	5.0%	9.1%
Non-Infected	100.0%	80%	82.4%	80.9%	95.0%	90.9%

$\chi^2_{5df} = 2.516$ $p = 0.642$

TABLE 25

EFFECTS OF MATERNAL MARITAL STATUS ON THE DEVELOPMENT OF SALMONELLOSIS

Status	Married (N=114)	Single (N=8)
Infected	15.8%	12.5%
Non-Infected	84.2%	87.5%

$\chi^2_{1df} = 0.061$ $p = 0.804$

TABLE 26

EFFECTS OF SOCIOECONOMIC STATUS ON THE DEVELOPMENT OF SALMONELLOSIS

Status	Upper (N=30)	Middle (N=27)	Lower (N=49)	Unclassified[1] (N=17)
Infected	16.7%	11.1%	14.3%	23.5%
Non-Infected	83.3%	88.9%	85.7%	76.5%

$\chi^2_{3df} = 1.324$ $p = 0.724$

[1] Includes unemployed and students.

TABLE 27

ONE-WAY ANALYSIS OF VARIANCE USING SALMONELLAL INFECTION AS THE DISCRIMINATING VARIABLE

Independent Variable	F-Ratio	Significance
Length of Hospitalization	86.490	0.0000
Birth Weight	30.470	0.0000
Nursery	36.000	0.0000
Antibiotics	18.800	0.0000
Gestational Age	15.090	0.0002
Head Circumference	14.750	0.0002
Breast-Fed	10.610	0.0015
Small for Gestational Age	8.788	0.0037
Phototherapy	8.788	0.0037
Mode of Delivery	7.556	0.0069
Anoxia	6.122	0.0147
Length at Birth	5.049	0.0265
Formula-Fed	4.827	0.0299
Maternal Age	2.484	0.1176
SES	0.708	0.4018
Maternal Parity	0.481	0.4893
Sex	0.193	0.6612
Mother's Marital Status	0.3440E-02	0.9533

TABLE 28

VARIABLES UTILIZED IN STEPWISE DISCRIMINANT ANALYSIS

Step Number	Variable Entered	Variable Removed	Wilks Lambda	Level of Significance
1	Length of Hospital-ization		0.583	0.000
2	NICU		0.538	0.000
3	Formula-Fed		0.510	0.000
4	Birth Weight		0.499	0.000
5	Photo-therapy		0.490	0.000
6	Caesarian Section		0.479	0.000
7		NICU	0.480	0.000
8	Head Cir-cumference		0.474	0.000

TABLE 29

CLASSIFICATION RESULTS USING CANONICAL DISCRIMINANT FUNCTION FOR "LENGTH OF HOSPITALIZATION"

Actual Group	No. of Cases	Predicted Group Membership	
		Infected	Non-Infected
Infected	19	14(73.7%)	5(26.3%)
Non-Infected	104	1(1.0%)	103(99.0%)

PERCENT OF CASES CORRECTLY CLASSIFIED: 95.12%

Discussion

Following the introduction of S. california into the nursery environment through an infant infected at parturition, dissemination of the bacterium appears to have continued for ten months. No contaminated environmental source could be located despite the frequent attempts to do so. It seems unlikely that a staff member would have been a fecal carrier for that length of time (Hornick, 1977). The higher proportion of cases among infants in NICU could be a result of interplay between increased susceptibility (Klaus and Fanaroff, 1973) and exposure to a reservoir of Salmonellae.

Prospective culturing yielded three additional cases while in the retrospective community survey the investigation found only one which was possibly attributable to the nosocomial outbreaks. The community case had been discharged only three weeks prior to the birth of the next hospital-associated case. The research instrument was not useful in detecting Salmonellal infection.

The duration of the Salmonella carrier state was consonant with that reported in the literature (e.g., Rowe et al., 1969). It did not appear to be influenced by antibiotic usage within the hospital, however, contrary to the findings in the literature reviewed earlier (Aserkoff and Bennett, 1969; Dixon, 1965).

Discriminant analysis revealed that "length of hospitalization" was the best predictor of Salmonellal infection in these outbreaks. Several factors may account for this finding. Firstly, the infants who were hospitalized longer would be more at risk of exposure to the reservoir of infection. Secondly, the infants who were in hospital for longer periods of time were likely to be those who were more susceptible due to their prematurity (Bellanti and Hurtago, 1976), or due to illness. Thirdly, illness during the neonatal period has been associated with abnormal colonization of the gut with gram-negative bacilli (Goldman et al., 1978).

Of the other factors which were implicated by the discriminant analysis procedures as influencing Salmonellal infection, "low birth weight," "small head circumference," "phototherapy," and "Caesarian-section deliveries" would all be responsible for the infant being placed in NICU.

The discriminant analysis procedures also indicated that infants who were formula-fed were more at risk of developing Salmonellosis than were breast-fed infants. As no Salmonellae were cultured from the formula specimens submitted for analysis, the formula itself was not contaminated. Breast-feeding, however, protects the infant from enteric infections by allowing the development of a stable intestinal flora (Haenel, 1970), and by enhancing the infant's resistance by supplying secretory IgA (Grams, 1978).

The maternal factors of age, parity, SES, and marital status did not influence infection with S. california.

Study of Growth Patterns in Infected Infants

Turning to the results of the study on growth patterns, the reader is reminded that serial measurements of weight, length, and head circumference were taken at birth, 3 months, and 6 months of age on infants (N=110) born during the outbreaks. Measurements of weight and length were also collected at 12 months of age. (The parameters of these measurements are included in Appendix D.) Growth is being measured as the rate of change between successive anthropormorphic measurements. Only measures accounting for greater than 1% of the total variance are discussed.

Growth from Birth to Three Months of Age

Three sets of measurements of growth were considered: increased weight, increased length, and increased head circumference. The independent variables are: mode of delivery; sex; gestational age; nursery; length of hospitalization; diet at birth; maternal age; parity; marital status and socioeconomic

status; antibiotic therapy; phototherapy; diet at three months; and history of diarrheal illness at 3 months.

Weight Gain to Three Months of Age

In Table 30 the factors influencing weight gain between birth and three months are noted. Salmonella infection negatively influenced growth, accounting for 24% of the total variance. This is consistent with the findings of Cole and Parkin that gastrointestinal infection can decrease weight gains (1977). Both lower and middle socioeconomic class had a measureable affect on the total variance. While Stunkard et al. noted a strong relationship between working class and obesity at 6 years of age, their data do not cover observations in infancy (1972). Both low forceps deliveries and Caesarian-sections were associated with growth. It may be postulated that infants may require assistance of that nature when they are large at birth. As larger infants tend to gain weight more quickly than smaller infants (Neumann and Alpaugh, 1976), this could account for the appearance of "mode of delivery" as an important variable influencing growth.

"Having been in NICU" is noted here to have a negative influence on growth. As these infants are frequently ill, this

TABLE 30

FACTORS INFLUENCING WEIGHT GAIN BETWEEN
BIRTH AND THREE MONTHS OF AGE

	R Square	RSQ Change	Simple R	Beta
Salmonella	0.24	0.236	-0.485	-0.551
Middle Class	0.26	0.026	0.191	0.119
Low Forceps Del.	0.28	0.021	0.147	0.163
Caesarian Section	0.29	0.016	-0.014	0.263
Lower Class	0.31	0.013	0.028	0.31
NICU	0.32	0.010	-0.262	-0.178
Days in Hospital	0.33	0.015	-0.244	0.201

finding is not illogical. "Length of hospitalization," which is also associated with placement in NICU, had an influence on growth in this study. The correlation between growth and length of hospitalization was negative.

Linear Growth at Three Months of Age

The negative influence of Salmonellal infection accounted for 34% of the total variance in linear growth between birth and three months of age (Table 31). This is contrary to the findings of Condon-Paoloni et al. (1977) who reported that height was not affected by gastroenteritis in their study. "Middle class" again exerted a positive influence accounting for another 2% of the total variance. "Low forceps delivery," "lower class," and "delivery by Caesarian-section" accounted for a further 4% of the total variance. Consistent with the findings on weight gain, NICU again had a negative influence on growth while "length of hospitalization" was again negatively correlated with growth. "Gestational age," "phototherapy," and "diarrhea within the first three months" accounted for only a further 3.5% of the total variance. In total, 48.7% of the variance was accounted for.

TABLE 31

FACTORS INFLUENCING LINEAR GROWTH BETWEEN BIRTH AND THREE MONTHS

	R Square	RSQ Change	Simple R	Beta
Salmonella	0.348	0.348	-0.590	-0.659
Middle Class	0.367	0.020	0.178	0.229
Low Forceps Del.	0.387	0.019	0.153	0.703
Lower Class	0.403	0.016	0.059	0.098
Caesarian Section	0.415	0.012	-0.067	0.242
NICU	0.430	0.016	-0.339	-0.281
Days in Hospital	0.450	0.020	-0.307	0.310
Gestational Age	0.466	0.016	0.276	0.141
Phototherapy	0.476	0.010	-0.147	0.133
Diarrhea at Three Months	0.487	0.011	0.133	0.109

Growth in Head Size at Three Months of Age

Again, Salmonellal infection accounted for the largest proportion of the explained variance: 36% (Table 32). "Length of hospitalization," "gestational age," and "low forceps delivery" accounted for an additional 3% of the total variance. All three named social classes had a positive influence on growth in head circumference. The SES group which is unnamed and around which the named classes can vary are the unemployed and/or students. Again "NICU" has a negative influence on growth. "Caesarian-section delivery" and "phototherapy accounted for 2% of the total variance.

Factors Influencing Growth Between Three and Six Months

In addition to the factors included in the analysis to three months, history of diarrheal illness between three and six months is included as an independent variable. Measurements of growth are again available for weight, length, and head circumference.

TABLE 32

FACTORS INFLUENCING INCREASED HEAD CIRCUMFERENCE BETWEEN BIRTH AND THREE MONTHS

	R Square	RSQ Change	Simple R	Beta
Salmonella	0.370	0.370	-0.608	-0.706
Days in Hospital	0.387	0.017	-0.293	0.302
Gestational Age	0.406	0.019	0.263	0.092
Low Forceps Del.	0.418	0.012	0.152	0.148
Middle Class	0.434	0.015	0.123	0.260
Lower Class	0.448	0.014	0.120	0.240
Upper Class	0.456	0.008	-0.047	0.124
Caesarian Section	0.467	0.010	-0.094	0.241
NICU	0.486	0.020	-0.354	-0.279
Phototherapy	0.501	0.014	-0.123	0.144

Weight Gain from Three to Six Months

A diet factor - drinking skim, partially skimmed, or whole milk by three months of age - had a negative influence on growth during this period of time (Table 33). This accounted for the largest proportion of total variance (10%). It is not possible in this study to determine which of the three dairy diets was utilized. In the literature, whole milk is associated with increased weight gain, while skim milk is associated with decreased weight gain (Neumann and Alpaugh, 1977). Two other negative influences, "breech delivery" and "diarrheal illness in the first three months of life," accounted for a further 7%. The negative influence of Salmonellal infection accounted for less than 1% of the variance during this time. Association with the first epidemic period had a positive influence on growth. Because these infants were born during the summer months, the effect may be due to seasonal variations in growth. Again, delivery via Caesarian-section was associated with growth although only accounting for 1% of the total variance.

Linear Growth from Three to Six Months

Six factors accounted for only 20% of the total variance (Table 34). The four factors most influencing growth had nega-

TABLE 33

FACTORS INFLUENCING WEIGHT GAIN
BETWEEN THREE AND SIX MONTHS

	R Square	RSQ Change	Simple R	Beta
Milk at Three Months	0.011	0.101	-0.318	-0.290
Breech Delivery	0.142	0.041	-0.282	-0.212
Diarrhea at Three Months	0.172	0.024	-0.148	-0.232
First Outbreak	0.201	0.028	0.164	0.142
Lower Class	0.221	0.020	0.161	0.164
Diarrhea at Six Months	0.240	0.019	0.113	0.126
Salmonella	0.250	0.008	-0.127	-0.125
Caesarian Section	0.261	0.012	0.096	0.139

TABLE 34

FACTORS AFFECTING LINEAR GROWTH BETWEEN THREE AND SIX MONTHS

	R Square	RSQ Change	Simple R	Beta
Milk at Three Months	0.081	0.081	-0.785	-0.265
Breech Delivery	0.121	0.039	-0.268	-0.206
Middle Class	0.156	0.036	-0.172	-0.158
Diarrhea at Three Months	0.177	0.021	-0.123	-0.197
Diarrhea at Six Months	0.194	0.017	0.088	0.148
First Outbreak	0.205	0.011	0.12	0.114

tive impacts. These included "early introduction of milk," "breech delivery," "middle class," and "diarrhea at three months." It is interesting to note that "middle class" had a positive effect on growth measured as weight change, but a negative influence on linear growth. Why "breech delivery" would negatively influence linear growth at 6 months and not earlier is not clear.

Diarrhea, as noted earlier, does not usually affect linear growth unless it is severe and prolonged. In this instance, "diarrhea at 3 months of age" had a negative influence on growth, as judged by the impact on the total variance accounted for, while diarrhea at 6 months had a positive (albeit small) influence on growth, accounting for less than 2% of the total variance. Association with the first epidemic period accounted for 1% of the change in variance.

Growth in Head Circumference from Three to Six Months

Only four factors contributed more than 1% change in variance (Table 35). These factors only accounted for 13% of the total variance. The first three, "milk," "middle class," and "breech delivery" had a negative impact on growth. The diet factor and "breech delivery" were noted to be negatively associated with linear growth and weight gain during this period as

TABLE 35

FACTORS INFLUENCING GROWTH IN HEAD CIRCUMFERENCE BETWEEN THREE AND SIX MONTHS

	R Square	RSQ Change	Simple R	Beta
Milk at Three Months	0.067	0.064	-0.252	-0.157
Middle Class	0.097	0.030	-0.162	-0.181
Breech Delivery	0.122	0.025	-0.225	-0.145
Maternal Age	0.132	0.010	0.134	0.165

well. "Maternal age" made a small positive contribution to growth.

Factors Influencing Growth Between Six and Twelve Months

To the list of independent variables at the previous level, history of "diarrheal illness between 6 and 12 months" was added. As only measurements on weight and length were available at 12 months, head circumference data are not discussed.

Weight Gain Between Six and Twelve Months

Five factors accounted for 12% of the total variance of growth between six and twelve months (Table 36). "Gestational age" appears to have more of an influence during these later months than was noted during the first six months. Infants who are pre-term but not small for their gestational age should catch-up to the full-term infant by three years of age (Babson and Benda, 1976). While measurements have been adjusted for pre-term infants to modify the effect of prematurity, some other aspect of "being born early" seems to have shown an effect here, accounting for 3.5% of the total variance.

Again, "length of hospitalization" had a positive influence on growth, accounting for a further 3.5% of the total variance.

TABLE 36

FACTORS INFLUENCING WEIGHT GAIN BETWEEN SIX AND TWELVE MONTHS

	R Square	RSQ Change	Simple R	Beta
Gestation	0.035	0.035	0.187	0.328
Days	0.070	0.035	0.053	0.294
Lower Class	0.090	0.021	-0.082	0.154
Diarrhea at Six Months	0.103	0.012	0.117	0.042
Mid Forceps Del.	0.116	0.013	0.119	0.131
First Outbreak	0.126	0.010	0.069	0.091

In this stage "lower class" emerged as a negative effect on growth. "Diarrhea at 6 months" still exerted a positive influence for some reason, as did "mid forceps delivery."

Linear Growth Between Six and Twelve Months

Sixteen percent of the total variance was accounted for by 6 variables (Table 37). The impact of the factors which were influential at birth was lessened by increasing time. As with growth measured by weight, "gestational age" accounted for the largest proportion of total variance in linear growth, and "lower class" again exerted a negative influence. "Mode of delivery" had an important influence on growth through both "low forceps delivery" which was negatively correlated with growth, and "breech delivery" which was now positively correlated with growth. Maternal age and parity both positively influenced growth. They may, in this instance, represent the effect of the mother's experience in "mothering."

Growth From Birth to Twelve Months of Age

In the following section, variables accounting for greater than 1% of the total variance in growth as measured between birth and twelve months of age are presented. Due to the lack of

TABLE 37

FACTORS INFLUENCING LINEAR GROWTH
BETWEEN SIX AND TWELVE MONTHS

	R Square	RSQ Change	Simple R	Beta
Gestation	0.054	0.054	0.231	0.309
Lower Class	0.090	0.037	-0.163	-0.195
Low Forceps Del.	0.112	0.021	-0.160	-0.162
Antibiotics	0.127	0.015	0.105	0.106
Breech Delivery	0.137	0.009	0.048	0.119
Maternal Age	0.147	0.011	0.111	0.193
Parity	0.164	0.017	-0.061	-0.124

measurements of head circumference, only growth measured as weight and height are considered.

Weight Gain From Birth to Twelve Months

As shown in Table 38, "Salmonellal infection" while only accounting for 5.8% of the total variance for growth, still exerts an important influence on the pattern of infants during the first year of life. Gestational age, accounting for a 2.3% increase in variance, became an important factor in the overall picture as well. "Length of hospitalization," "diarrhea at 6 months of age," negative influenced the total growth picture for the first 12 months of life, and maternal age, positively correlated with growth, accounted for 1% of the total variance.

Linear Growth From Birth to Twelve Months

Salmonellal infection was shown in these analyses to be an influencing factor on linear growth as well as during the first 12 months of life (Table 39). Factors which affected weight gain, "gestational age," "maternal age," "mid forceps delivery," and "length of hospitalization" were also influencing factors for gains in length by 12 months. Antibiotic therapy during the neonatal period, which had not been noted to influence growth on

TABLE 38

FACTORS AFFECTING WEIGHT GAIN
BETWEEN BIRTH AND TWELVE MONTHS

	R Square	RSQ Change	Simple R	Beta
Salmonella	0.058	0.058	-0.241	-0.362
Gestational Age	0.084	0.029	0.232	0.297
Length of Hospitalization	0.136	0.052	-0.058	0.372
Diarrhea at Six Months	0.151	0.015	0.144	0.121
Mid Forceps Del.	0.164	0.013	0.126	0.187
Maternal Age	0.180	0.016	-0.05	-0.138

TABLE 39

FACTORS AFFECTING LINEAR GROWTH FROM BIRTH TO TWELVE MONTHS

	R Square	RSQ Change	Simple R	Beta
Salmonella	0.118	0.118	-0.344	-0.391
Gestation	0.173	0.055	0.336	0.309
Antibiotics	0.206	0.032	0.034	0.144
Diarrhea at Twelve Months	0.223	0.017	0.169	0.089
Maternal Age	0.233	0.010	0.169	0.103
Mid Forceps	0.245	0.012	0.115	0.123
Lower Class	0.254	0.009	-0.077	-0.132
Length of Hospitalization	0.267	0.012	-0.209	0.194

any of the previous parameters, surfaced as a positive force, accounting for a 3% increase in total variance. Diarrhea during the second six months of life appeared to have an effect on the total linear growth pattern for the first year of life as well, although again the reason is not clear.

Discussion

Salmonellal infection exerted an influence on growth whether measured in terms of weight, length or head circumference throughout the first year of life. The effect was most noticeable, as might be expected, in the measurements taken during the first three months following infection. In measuring growth between 3 and 6 months, Salmonellal infection accounted for less than 1% of the total variance associated with weight gain. No effect was recorded for either linear growth or head circumference. In considering the variables associated with growth patterns over the entire year, the negative influence of Salmonellal infection remained measureable. While there were no studies which the investigator found that dealt specifically with the effects of Salmonellal infection on subsequent growth patterns, other authors (e.g., Cole and Parkin, 1977; Condon-Paoloni et al., 1977) have noted that repeated gastrointestinal illness can negatively affect growth. Following correction of the problem,

catch-up growth is usually noted providing that adequate nutrition is available (Falkener, 1977). No effect of infection on height or head circumference has been noted previously in the literature.

In this study, phototherapy, which was negatively correlated with linear growth and growth in head circumference, only exerted an influence during the first three months of life. This is consonant with the early findings of Wu et al., in 1974. The fact that no influence was found during the later months supports work done by Teberg et al. (1977).

The negative effect of having been in NICU was consistent across the growth parameters during the first measurement period. As explained earlier, part of this influence may be due to the fact that these children were in NICU because they were ill, giving them a disadvantageous start to life compared to their healthy birth cohorts. The effect was not noticeable after 3 months of age. Presumably, the phenomenon of catch-up growth was again in effect then.

"Length of hospitalization" was also negatively correlated with growth. The effects of this variable were noticeable throughout the study. Some of the explanation given for the association of "NICU" with decreased growth may be applicable here as well.

Interestingly, infants who were SGA were not noted to have growth patterns that were greatly altered from those of their larger birth cohorts. Babson and Benda note that infants who are small for their gestational age show progress, but do not fully catch-up to infants who were within normal limits for size at birth (1976). In this study, the rates at which the SGA infants grew did not seem to be a major factor influencing the overall growth patterns of the infants.

While males are noted in the literature to gain weight at a faster rate than females (Neumann and Alpaugh, 1976), this was not noted to be a factor here. Anoxia at birth did not appear to influence later development either.

Of the maternal factors considered, parity and age were both positively correlated with growth during the later developmental phases. This may be possibly explained as the effect of "experienced mothering." Marital status did not influence growth in this study.

The effects of social class are not clear in this study. "Lower class" accounted for a very small (but positively correlated) proportion of the total variance of growth up to 6 months of age. After that, it was associated with an equally small proportion of total variance, but with a negative influence. "Middle class" shared a similar relationship to growth. The variable "upper class" was noted only once with a small

negative influence on head circumference at three months. It is probable, judging by the very small changes of total variance attributable to the presence of these factors, that social class did not dramatically influence growth in terms of this study.

"Mode of delivery" kept surfacing throughout the study as influencing growth patterns. As suggested earlier, part of this influence may have been due to the need for assisted methods of delivery (e.g., forceps or Caesarian-section) for larger infants. Size at birth is known to influence subsequent rates of growth (Garn et al., 1977; Neumann and Alpaugh, 1976). Breech delivery, which was negatively correlated when exerting an influence, is associated with developmental problems (Korones, 1976). This may account for its negative influence on growth in this study.

The early introduction of milk products did not positively alter growth patterns. It accounted for small but negative proportions of total variance in growth. Some of the possible reasons for this were discussed earlier. "Diarrheal illness" was not predictable in its effect on growth. The fact that its influence at each level of measurement could vacillate between positive and negative effects leads this investigator to question if the incidence of diarrheal illness was totally accounted for by this measure.

General Discussion

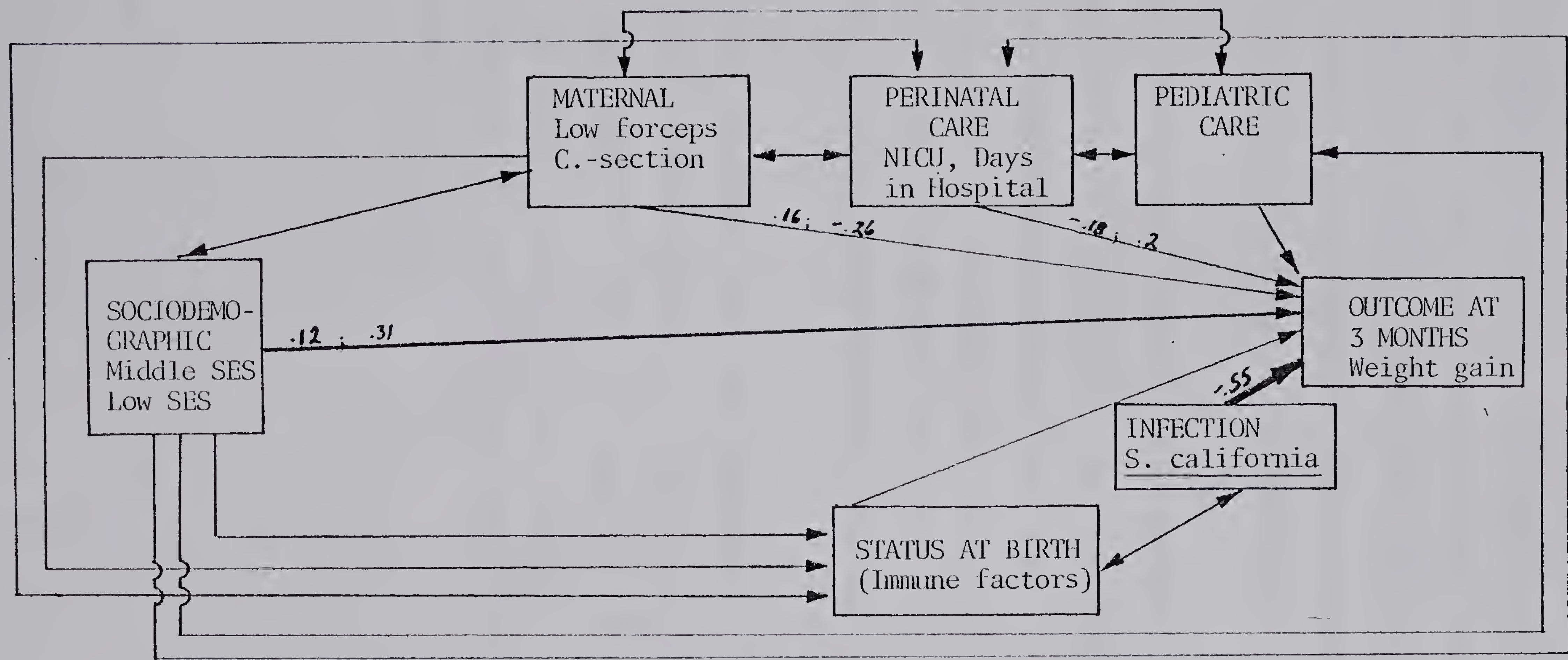
In the first phase of this study, the contribution of the selected independent variables on the development of neonatal nosocomial Salmonella infection was examined. In the second phase, an attempt was made to examine the influence of these variables on the subsequent growth of the infants involved. Some of the independent variables noted to affect rates of infection - e.g., "nursery" and "length of hospitalization" - continued to influence later growth.

The interrelationships of the major variables can perhaps be explained more clearly by the use of a model. Figure 4 demonstrates the relationships among the key variables used in this study. As the reader will have noted, the variables influencing outcomes varied according to the time period for which measurements were taken. Therefore, for illustrative purposes, growth measured by weight gain at 3 months will be examined.

For the purpose of analysis in Figure 4, independent variables have been assembled under the following category headings: sociodemographic; maternal; perinatal care; pediatric care; infection; and outcome. Influences on growth which were noted in the multiple regression analyses - "S. california," "middle class," "low forceps," "Caesarian-section," "lower class," "NICU," and "days in hospital" - have been placed in the corresponding

FIGURE 4

RELATIONSHIPS AMONG VARIABLES AFFECTING GROWTH AT THREE MONTHS



category. The magnitude of the relationships among these variables is depicted through the use of the beta weights cited on the arrows joining the variables. These arrows can then be used to further illustrate the relationships through the relative thickness with which they are drawn, and the direction in which they are pointed.

In Figure 4, the relative importance of "infection" is visible through the use of a thick arrow. The "sociodemographic" category has the second largest influence as evidenced by the thickness of that arrow. It is assumed that the variables within the categories can change depending on the measure of growth utilized, and the timeframe within which the measurements were taken.

It was beyond the scope of this study to examine all of the influences noted in the literature review to affect growth. Nevertheless, the influence of many of the major factors has been illustrated. The factor exerting the greatest influence on "growth" in infants in this study during the first year of life was infection with S. california.

CHAPTER V

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

Summary

While there are many reports of Salmonella infections in nurseries, few authors have directed their investigations towards the identification of specific factors predisposing to infection or towards exploring the results of the infection in terms of subsequent growth patterns in the infants. This study was undertaken to explore the influence of selected neonatal, maternal, and environmental factors on the development of Salmonellosis. Subsequent to the initial phase of the outbreak investigation, the influences of the above factors and of infection on growth were assessed.

In July 1977, *S. california* was probably introduced into the newborn nursery of a large city hospital by a neonate infected at birth. Following the infection of the index case, the transmission of the organism to seven other infants appears to have been by cross-infection rather than exposure to a common vehicle such as formula.

All of the cases occurred among infants in the neonatal intensive care unit under study. Phototherapy, which is used to

treat hyperbilirubinemia in neonates, was significantly associated with an increased rate of Salmonella infection. This association may have been due to fecal contamination of the equipment used. (The index case received phototherapy.)

One of the factors which may have influenced the spread of the disease was failure to isolate infants who had frequent loose stools. In one instance, antibiotic therapy was initiated to treat diarrhea two days prior to isolating the infant. The institution of strict isolation procedures and the closure of the wards to further admissions appeared to be effective in halting the outbreak.

Six months later, S. california was again noted in six neonates at the hospital. While the majority of cases were in the NICU, two cases appeared among infants in the normal nursery during this outbreak. Once again there was a significant association with treatment with phototherapy.

While the organism could have been reintroduced to the hospital environment by another parturiant mother, the similarity of the antibiotic sensitivity pattern to that noted in the earlier outbreak and the lack of other cases of S. california in the community tended to point towards propagation from the original outbreak. This could have occurred through fecal carriage by staff, or through exposure to a contaminated environ-

mental source. No staff carriage of S. california was noted in stool screening during either outbreak.

To test the thesis that dissemination of the organism had occurred between the outbreaks, a stool screening survey was conducted on all infants who had been in the NICU between the outbreaks. The NICU population was chosen for the survey as these infants exhibited the highest attack rates during both outbreaks. In addition, a prospective stool screening program for all infants born in the hospital was set up. Infants had stool cultures taken on the fifth day of life or on discharge, which ever came first.

The community survey yielded one additional case, an infant born in November, 1977. He had been discharged just three weeks prior to the birth of the index case in the second outbreak. While no proof exists that the infant was infected nosocomially, there is certainly a warranted suspicion due to his association with the NICU. A questionnaire designed to look at stool characteristics associated with the development of Salmonellosis did not appear to be helpful in identifying cases of Salmonellosis in the community.

The prospective study yielded a further three cases over the next three months, all associated with residence in NICU. This finding gave credence to the theory that dissemination of Salmonellae had continued since the original outbreak. Despite num-

erous attempts to discover the source, no environmental swabs ever yielded positive cultures.

The extended course of the second outbreak was probably due to three factors: (1) failure again to isolate all infants who were having increased bowel movements; (2) failure to recognize that some infants were exhibiting abnormal stool characteristics; and (3) the decision by management not to close the newborn nurseries to further admissions.

A study of predisposing factors indicated that the length of hospitalization was the best predictor of susceptibility to infection. In addition, size at birth, treatment with phototherapy, and delivery by Caesarian-section were all implicated causally. The above factors are all associated with placement in NICU. Formula-feeding also predisposed to Salmonellosis. This is the result of formula-fed infants being more prone to enteric infections than breast-fed infants. The formula itself was not contaminated.

In assessing subsequent growth patterns in infants born at the hospital during the epidemic periods, Salmonella california was noted to affect all parameters of growth considered - head circumference, length, and weight - with the effect being most noticeable during the first three months. Other factors noted to

influence the acquisition of the disease, namely phototherapy, and length of hospitalization, also affected growth during the first three months.

The maternal factors of age and parity appeared to assume a more important role in growth in infants during the later months of the first year of life. However, the independent variables selected accounted for a considerably smaller proportion of total variance during the last six months than during the first three.

Sex of the infant, marital status of the mother, and anoxia at birth did not affect growth in this study. Lower and middle SES were associated with higher rates of growth during the first three months of life, and lower rates during the second half of the infant's first year.

The major specific findings in this study were as follows: Salmonella california, after introduction into a nursery environment was disseminated for several months. Length of hospitalization was the single factor which most influenced acquisition of the disease. Once neonates had become infected, the negative influence on their growth patterns as measured by gains in weight, length, and head circumference could be detected over the next three months.

Implications for Nursing Care

In Chapter II, it was noted that nurses have a major responsibility for the control of infections within the hospital environment (Chavigny, 1977). Many authors indicate that nurses have been negligent in handwashing procedures and have consequently propagated infection in this manner (e.g., Adler, et al., 1970; Cragg, 1979; Watt et al., 1958). This is not a factor which has relevance only for nursing, however. It should be remembered that all personnel who have contact with these vulnerable neonates must conscientiously ensure that infections are not passed from infant to infant. Infants in NICU have many caregivers from many disciplines. Cragg argues that nurses should be guardians for their patients as they (nurses) have the knowledge of correct procedures (1979). This function should be monitored by supervisory nursing staff to ensure patients are adequately protected.

During this investigation, two major problems associated with nursing practice were noted. Firstly, although nurses were recording abnormalities in infants' stool characteristics, they did not always identify that there was a problem. It should be emphasized here that the stools of newborns tend to be liquid in nature. In addition, meconium produces a greenish tinge to the feces. As phototherapy can also induce episodes of more frequent

stooling, the problem of recording and reporting observations appears to be quite complicated. Nevertheless, differences in stools between infected and non-infected infants were distinctive. The nurses' powers of observation were accurate enough. The problem lay in their not taking appropriate action on the basis of their findings.

The second problem pertains to the isolation of infants suspected of being infected. It would appear from reading the nurses' notes on the charts of the nosocomial cases that initiative for generating isolation "orders" was the prerogative of the attending physician only. This may well have been the cause for the delay in isolating many of the infants. While this investigator most assuredly does not advocate interference with the physician's authority to order isolation procedures, the adoption of a policy whereby nurses could use their own initiative when necessary to separate infants noted to be having frequent loose stools from their cohorts could potentially decrease cross-infection within the nursery. It should be noted that this last item was put into effect during the second outbreak by the Infection Control Officer. (See Appendix C.)

Infection can have serious sequellae for vulnerable neonates. Knowledge of factors predisposing to infection, cognizance of mechanisms effective in interrupting the transmission of

infection, and recognition of the signs and symptoms of infection are basic requisites for the provision of safe nursing care.

Recommendations for Further Research

On the basis of the unique findings in this study of a negative effect on the measured parameters of growth during the first three months of life following neonatal infection with Salmonella, the investigator strongly recommends that a replication of the study be undertaken when the opportunity occurs. Rather than limiting the study to the implications of Salmonellal infections only, consideration should be given to examining the influence on growth of other enteric pathogens. Secondly, in any such research, particular attention should be given to the complex methodological problems surrounding the analysis of growth data, using growth as a dependent variable.

In replicating the study, this investigator recommends that future stool screening surveys of infants or staff utilize only stool specimens, rather than accepting rectal swabs for culturing purposes, and that the number of specimens collected be no fewer than two in order to increase the accuracy of the results.

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APPENDIX A

GLOSSARY OF TERMS

GLOSSARY OF TERMS

AGENT: a biological, physical, or chemical substance capable of causing disease.

ATTACK RATE: measure of frequency of occurrence of an event within a specified time frame for a narrowly defined population.

CARRIER: an infected person (or animal) harbouring a specific infectious agent without having discernible disease.

CASE: a person who is harbouring a specified disease defined either by clinical, laboratory, or epidemiological characteristics.

COHORT: a group of persons selected for inclusion in a group on the basis of birth within a specified time interval.

CONTACT: a person who has associated with someone known to have a specific infectious disease.

CONTAMINATION: the presence of an infectious agent on a body surface, an inanimate object, or in food or beverage.

EPIDEMIC: the occurrence of cases of a disease in excess of normal expectancy in human populations.

Common-source epidemic - an epidemic of disease in which one person or vehicle is responsible for the transmission of the disease to the remaining cases.

Propagated-source epidemic - an epidemic in which transmission has occurred as a result of person-to-person spread.

ENVIRONMENT: extrinsic biological, social, and physical factors which potentially influence the development of disease.

FOMITE: inanimate object which may become contaminated and serve as a means of transmitting organisms.

HOST: organism capable of being infected by a specific agent.

INCIDENCE: the number of new cases of a disease in a specified population occurring within a specified time interval.

INCUBATION PERIOD: the time interval between effective exposure to a disease agent and the onset of symptoms of illness.

INDEX CASE: the first case to occur among a number of epidemiologically related cases.

INFECTION: the entry and multiplication of a disease causing agent within living tissues resulting in cellular damage.

Inapparent infection: infection occurring without manifest signs or symptoms.

Apparent infection: infection resulting in clinical signs and symptoms of disease.

NOSOCOMIAL INFECTION: infection developing as the result of exposure to a disease causing agent in a health care facility.

OUTBREAK: the occurrence of two or more cases which are epidemiologically related.

PATHOGENICITY: the capacity of an infectious agent to cause disease.

PREVALENCE: the number of cases of a disease in the defined population at a given time.

RESERVOIR: the living organism or inanimate matter in which an infectious agent can live and multiply, and from which it can be transmitted to a susceptible host.

SURVEILLANCE: the continuing scrutiny of all aspects of disease occurrence and transmission that are relevant for controlling its spread.

VEHICLE: substance which serves as source of infection.

VIRULENCE: the ability of an agent to produce serious illness.

SOURCES

Health Education and Welfare, Public Health Service Bureau, Centre for Disease Control. Glossary of terms used in epidemiology. HEW Publication No. 00-2503, 1974.

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APPENDIX B

QUESTIONNAIRE

THE CITY OF Edmonton
7th Floor, CN Tower
10004-104 Avenue
Edmonton, Alberta
T5J 0K1

HEALTH DEPARTMENT

April, 1978

Dear Parent:

Several organisms are known to cause diarrhoea in infants. We are currently attempting to find out how common these organisms are in the Edmonton area by testing young babies' stool (bowel movement).

As babies can have the organisms without having diarrhoea, it is necessary to check healthy babies as well as those having loose bowel movements. We would sincerely appreciate your giving us a sample of your baby's bowel movement in the container provided, and filling out the questionnaire. Your answers will be kept completely confidential.

Thank you.

Margaret King
Nurse Epidemiologist.

MK/kw

Q U E S T I O N N A I R E

This questionnaire is to be filled out by parents submitting a specimen of their babies' stools.

1. Baby's Name: ______________________________

2. Baby's Birthdate: ______________________

3. Baby's Sex: ____________________________

4. Today's Date: __________________________

Please check ( ) appropriate answers for questions 5 to 8.

5. Have you noticed any of the following in your baby's bowel movements:

   a) blood: no ____ yes ____ If so, when ______________

   b) mucous or slime: no ____ yes ____ If so, when ______________

   c) watery green colour: no ____ yes ____ If so, when ______________

6. Has your baby ever had a noticeable increase in the number of deaily bowel movements for which you have not known the cause?

   no ____ yes ____

   If so, when ______________________________

7. Has your baby had any diarrhoea for which he/she has been treated by a doctor?

   no ____ yes ____

   If so, when did the disease occur and when was he/she treated?

   ____

8. Has your baby ever been on any antibiotics?

   no ____ yes ____

   If so, what medication was he/she given (if you can remember and when?

   ____

Thank you very much for your assistance.

April 6th, 1978

Re: Salmonella at the Hospital

As you know, there have been two outbreaks of Salmonella california at the Hospital in the newborn nursery. While salmonella infections in newborns often are associated with a high mortality rate, there have not been any deaths associated with either outbreak. Nevertheless, this is certainly still a potential risk should there be any further cases.

We were able to trace the source of the first outbreak but to date, the source of the second outbreak has eluded us. As three infants have been totally asymptomatic, we need to know if there is any possibility that babes have been discharged between the two epidemic periods (July, 1977 - February, 1978). Contacting asymptomatic carriers in the community could feasibly give us some clue of the source of contamination. In addition, it could potentially eliminate the source of an epidemic in the community.

Most of the infants involved in the two outbreaks had been in the Intensive Care Nursery (12 out of 14). We are therefore planning to screen all infants who have been in the Intensive Care Nursery at the Hospital from August, 1977 - February, 1978. Realizing that this could make a drastic increase in your work load, we welcome all suggestions on how best to screen the babes with the least inconvenience to you and the parents.

Infants infected with salmonella tend to carry the organism much longer than adults to. Carriage up to one year of age is not uncommon, especially if antibiotics have been given at any point. We are hopeful that by collecting stool specimens we will still find a significant number despite the lapse in time.

Thank you very much for your help.

Margaret King
Nurse Epidemiologist

THE CITY OF Edmonton

7th Floor, CN Tower
10004-104 Avenue
Edmonton, Alberta
T5J 0K1

LOCAL BOARD OF HEALTH

Re: Salmonella Survey

As some of you have been asked questions by parents concerning the salmonella survey, I have drawn up some tentative guidelines. Dr. Infection Control Officer at the Hospital is in agreement with the focus of these statements:

1. All questions asked by parents should be answered truthfully.
2. Unless parents ask, do not mention that only babies from the Hospital are being tested.
   However, if parents ask, please tell them that one mother who was admitted to the hospital in labour did have salmonella. This was transmitted to her infant when she gave birth. As salmonella is easily transmitted among infants, we want to ensure that all babies are okay.
3. If they ask what organism we are looking for, feel free to tell them it is Salmonella.
4. The characteristics of Salmonella include those listed in items 5 and 6 of the questionnaire. As well, fever and vomiting may be present. Fever and vomiting however, were not prominent characteristics of those infected at the Misericordia.
5. Surveys are done at the discretion of Health Departments when the incidence of the disease warrants such a measure.
   They are undertaken to determine the extent of the problem.
6. If a baby has a stool culture which grows Salmonella, we will notify the parents. It will be about five days after the specimen is mailed before the results will be known. Only those with positive cultures will be notified.

Margaret King,
Nurse Epidemiologist.

MK/fy

THE CITY OF Edmonton

7th Floor, CN Tower
10004-104 Avenue
Edmonton, Alberta
T5J 0K1

HEALTH DEPARTMENT

Dear

As you may know, one of the hospitals in our city has recently experienced two outbreaks of Salmonella California in its' newborn nursery. While the source of the first epidemic in July, 1977 has been determined, the source for the outbreak in February, 1978 is still being sought. There is a possibility that infants with undetected infection have been discharged intermittently since August, 1977. The hospital is collecting stool specimens on all babies prior to discharge now, but we feel the problem is serious enough to warrant checking babies born between the two epidemic dates. The majority of infants infected were in the Intensive Care Nursery at the Hospital. Consequently, the Edmonton Health Department has set up a screening program to check all babies born between July, 1977 to March, 1978 who spent time in the Intensive Care Nursery following birth. Salmonella is carried for long periods of time in infants. For this reason we are hopeful of detecting carriers among any infants who may have been infected at the Misericordia Hospital during the last eight months.

Some of the babies who are in the proposed screening group live within your health unit area. We would appreciate your assistance in collecting stool specimens from these babies. A list of the babies in your area is enclosed along with a copy of the questionnaire which our nurses complete when collecting the stool specimen. Dr. Finlayson in the Provincial Laboratory of Public Health is in agreement with our screening program and is quite willing to process the extra specimens. To distinguish the screening specimens from normal lab. work, nurses are writing 'Salmonella California Survey' on the requisition and placing a "happy face ☺ " on the requisition as well.

We would really appreciate your assistance in this matter. As you know, Salmonella can be a dangerous illness in neonates. We feel the potential seriousness of the problem warrants our taking these extra steps to determine the nature and extent of the epidemic.

Yours sincerely,

Lorne J. Moat M.D.

APPENDIX C

CONTROL MEASURES

HOSPITAL
Edmonton, Alberta

INTERIM GUIDELINES FOR ISOLATION TECHNIQUE IN THE PREMATURE NURSERY (NEONATAL INTENSIVE CARE UNIT)

1. All newborn infants suspected of infection are to be transferred, in their cribs, to the designated area (outlined by floor tapes).

2. All equipment used for taking care of the baby is to be kept in the designated area. If equipment has to be removed from the area it must be cleaned as outlined in the Nursing Isolation Procedure.

   For cleaning of equipment and care of same, please refer to the Nursery Nursing Procedures.

3. When the category of infection is established, the appropriate Isolation Technique will be maintained, e.g. Strict Isolation, Wound and Skin Isolation, Enteric Isolation, Reverse Isolation.

4. All personnel who handle the infant or touch articles used for the infant must wear long sleeved isolation gowns. On leaving the area, wash hands in disinfectant solution by the crib, remove gown and wash hands in the sink.

5. Visitors

   Only one parent at a time may visit the infant after instructions regarding Isolation Technique are given by the nurse. The parent must be observed by the nurse. If more than one infant is on isolation, there is to be only one parent in the area at one time.

6. The infant will remain on separate technique until discharge.

Draft #2,
August 19, 1977

HOSPITAL
Edmonton, Alberta

March 1/78 SPECIAL MEETING, INFECTION CONTROL RE SALMONELLA CALIFORNIA OUTBREAK

The meeting was called to order by the Chairman at 0905 hours.

Dr. summarized the recent Salmonella California outbreak in the Hospital. It is a reoccurence of the strain introduced in the Intensive Care Nursery in August 1977.

The initial case occurred January 25 as diarrhea in a 48 hour old infant from the normal nursery. Isolation methods were instituted as soon as symptoms appeared. Survey cultures of mother and father as well as the other babes and mothers in the room were negative. The second case was reported February 14 in an infant in the Premature Nursery that had been cultured February 10. Survey cultures February 14 revealed three other infants with Salmonella California. The last case occurred in the normal nursery February 19. All cases have now been discharged. Survey cultures of environment and personnel have so far been negative.

The following points were discussed:

1. That there appears to be a common source -

   a. Environment: Case Room, bathing, feeding, traffic, equipment, procedures, bathroom.

      Moist swabs have been taken of equipment in contact with the infected area, ie. isolettes, suction tubes, stethoscopes.

      Methods used in bathing and feeding the babies, including temperature and use of the warming blanket, were discussed.

..../2

The factor of common bathrooms used by nurses and mothers was suggested.

Some of the babies were delivered in the same Case Room.

Cleaning equipment used by Housekeeping staff in the infected area was mentioned as a possibility.

b. Personnel: Surveying of Case Room staff, Intensive Care Nursery staff, Medical Staff, Housestaff, Post Partum staff, Housekeeping staff in contact with this area.

A program has been introduced through the Health Office to collect stool cultures from staff in contact with the nursery area.

Mrs. . noted a common factor of two R.N.s working in both the Observation Nursery and the Premature (Salmonella) Nursery. The R.N.s are on a rotation schedule so there are more than two in contact with this area.

Rooming-in: When a case of Salmonella was detected, the mother and baby were isolated and each mother and baby in that room were cultured.

2. Epidemiology - Time of onset, common factor, survey cultures.

3. Action -

a. The culturing survey will be continued with three stool cultures. Dr. will contact those Housestaff and Medical Staff that have not submitted cultures to the Health Office.

b. Swabing will be extended, ie. isolettes in the Observation Nursery, suction trap in Case Room.

c. In cooperation with the Public Health Department, our laboratory will conduct an extensive survey of future newborns from the Hospital. Ms. King will conduct a formal epidemiological survey and will organize a system of random selection of babies from the - — Hospital that come to the Jasper Place and Duggan Clinics. Dr. Finlayson will organize swabs and lab work involved.

The meeting was adjourned at 1010 hours.

(Recorded and Transcribed by)

HOSPITAL
Edmonton, Alberta

INTERIM GUIDELINES FOR ISOLATION OF BABIES ON MATERNAL-CHILD CARE AND/OR NORMAL NURSERY

Babies suspected of infection, other than enteric, should follow the procedure given below: (Please note attached re: Enteric)

1. On Days

Transfer to mother's room (either single, semi or 4-bed). Mother and baby isolated as unit. All equipment pertaining to baby's care should be kept in crib.

a. Long sleeved green gown to be worn by mum when handling baby.

b. I.V. pole to hang gown on.

c. Bowl of Wescodyne.

d. Stool.

e. Garbage can.

f. Laundry hamper.(to be handled as per Isolation Procedure)

Mum must be instructed in use of gown and hand washing and if isolation procedure is properly followed mum may then be allowed freedom to leave room.

Visitors - may visit with mum in Day Room only.
- father may visit in room with baby (may handle baby if he washes hands and gowns).

Baby must remain with mother for 24 hours until discharge. (Once on 3 East must not be transferred back to Nursery, but Nursery staff still responsible for baby's well being)

After discharge, clean equipment as per isolation procedure. Culture not necessary.

Prior to 10 p.m. follow above Procedure.

2. <u>On Evenings or Nights</u> (after 10 P.M.)

If infection suspected at this time, when baby is in Nursery, isolate baby in one corner of the Nursery.

Put red tape (or autoclave tape) on floor around crib area.

Set up isolation unit as follows:

1. Crib with baby's equipment.
2. I.V. pole for gown.
3. Stool.
4. Bowl of Wescodyne.

Baby to remain in isolation area in Nursery until 6 a.m. feed, when complete isolation unit may be transferred to mother's room.

Mother and baby now isolated as unit as above.

INFECTION CONTROL
OFFICER

March 2, 1978

PREMATURE AND N.I.C.

CLEANING AND MAINTENANCE OF EQUIPMENT

I. CRIBS:

a. Daily routine with night shift - each bed is washed with Wescodyne solution and dried. This includes plexiglass, base, and mattress.

b. Terminal cleaning is to include above procedure and in addition, the whole crib inside and out is done including drawer and shelves.

c. Report any broken or non-functioning parts.

II. ARMSTRONG INCUBATORS:

a. Daily routine - cleaning by night shift - wash lid, base, mattress, and window with Wescodyne and dry.

b. Refill reservoir with distilled water.

c. Replace burned out heat or indicator bulbs as needed.

d. Terminal cleaning to include reservoir heater and table.

e. Culture all incubators after terminal cleaning.

f. Allow to dry and air for 24 hours if possible.

III. THERMOMETERS:

Upon discharge, the alcohol is poured into used alcohol bottle and the thermometer and container are soaked in Wescodyne for five minutes, rinse, and dry.

IV. N.B.

N.I.C. staff - replace filters, suction apparatus, etc.

1. Isolette C85 replace filter q 3 months.
   C86 replace filter q 3 months.

   Armstrong isolette 188, replace filter q 4 months.

2. Isolettes to be oiled q 3 months.

3. Vapor jettes.
   Humidifiers.
   Suction equipment.
   O_2 Equipment.

   To be taken apart, washed, rinsed, and dried after each use. Suction tubes may be sterilized by boiling for re-use.

   Humidifier jars to be filled with sterile distilled water. All others with distilled water.

N.B. 1. Do not place gauges or mechanisms in water or other solutions.

2. Do not use alcohol on plexiglass.

V. CARE AND CLEANING OF ISOLETTES:

1. Daily routine at night - wash with Wescodyne and dry Dome, mattress, and tray.

2. Check reservoir and fill as needed with distilled water.

3. Report any broken or non-functioning parts.

Terminal Cleaning:

1. Remove to service room.

2. Remove and wash and dry mattress, trays, gaskets, sleeves, portholes, and inside heat and moisture tubes in old isolettes.

3. Wash dome base and cabinet inside and out.

4. Wash scale and hook.

5. Check and replace filters and date same as needed.

6. Replace sleeves as needed.

7. Allow to dry with dome open for 24 hours.

8. Ideally, do not use until negative culture returns.

9. C77 and C86 - motor removed for cleaning of sealed area by soaking in Wescodyne.

10. O_2 filter - wash and dry as needed (q 3 months).

11. Solutions for terminal cleaning - Acetic solution 1% and Wescodyne.

VI. 1. All special trays, e.g., scalp, umbilical infusion tray etc., are cleaned on ward and reset and sent to C.S.R. for sterilization.

2. Bath bowls and thermometers are sterilized on patient's discharge.

3. Other trays, e.g., bath trays, are washed and set up and sent to C.S.R. for sterilization, once in 24 hours, as these are used as "clean trays only."

APPENDIX D

PARAMETERS OF GROWTH MEASUREMENTS

TABLE 40

PARAMETERS OF THE WEIGHT MEASUREMENTS

1. Birth Weight (KG)	(a) range	1.5 to 4.2
	(b) median	3.3
	(c) mode	3.2
	(d) mean	3.3
	(e) std. deviation	.58
2. Weight at 3 Months (KG)	(a) range	4.2 to 7.9
	(b) median	5.9
	(c) mode	6.0
	(d) mean	5.9
	(e) std. deviation	.68
3. Weight at 6 Months (KG)	(a) range	5.7 to 9.9
	(b) median	6.7
	(c) mode	6.6
	(d) mean	6.7
	(e) std. deviation	0.39
4. Weight at 12 Months (KG)	(a) range	7.8 to 12.4
	(b) median	9.6
	(c) mode	8.8
	(d) mean	9.7
	(e) std. deviation	1.03

TABLE 41

PARAMETERS OF MEASUREMENTS OF LENGTH

1.	Length at Birth (CM)	(a) range	42 to 58
		(b) median	51.5
		(c) mode	50.0
		(d) mean	50.6
		(e) std. deviation	5.5
2.	Length at 3 Months (CM)	(a) range	52 to 71
		(b) median	61.3
		(c) mode	61.0
		(d) mean	61.2
		(e) std. deviation	3.1
3.	Length at 6 Months (CM)	(a) range	59 to 75
		(b) median	66.9
		(c) mode	66.0
		(d) mean	67.0
		(e) std. deviation	2.9
4.	Length at 12 Months (CM)	(a) range	65 to 87
		(b) median	75.6
		(c) mode	74.0
		(d) mean	75.5
		(e) std. deviation	3.6

TABLE 42

PARAMETERS OF HEAD CIRCUMFERENCE

1.	Head Circumference at Birth (CM)	(a) range	28 to 40
		(b) median	34.8
		(c) mode	34.0
		(d) mean	34.7
		(e) std. deviation	1.82
2.	Head Circumference at 3 Months (CM)	(a) range	35 to 44
		(b) median	40.5
		(c) mode	41.0
		(d) mean	40.3
		(e) std. deviation	2.1
3.	Head Circumference at 6 Months (CM)	(a) range	40 to 49
		(b) median	43.2
		(c) mode	43.0
		(d) mean	43.3
		(e) std. deviation	1.5